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SCHOOL SCIENCE

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National Council of Educational Research and Training

TEXTBOOKS

One of the first problems that engaged the attention of the National Council of Educational Research and Training was with regard to the preparation and production of improved textbooks for the school stage. For this purpose, the Council set up in 1962 on a permanent basis and with comprehensive terms of reference, a Central Committee on Educational Literature, which is responsible for drawing up the programmes of preparing textbooks and other instructional materials and to have these programmes implemented.

The Committee has since set up the following Panels of Experts to prepare textbooks:—

(1) Physics
(2) Chemistry
(3) Biology
(4) Mathematics
(5) General Science
(6) History
(7) Geography
(8) Hindi
(9) Sanskrit
(10) Commerce
(11) Technology
(12) Agriculture

Textbooks on the following subjects have been brought out by the Council.

BIOLOGY TEXTBOOK

The Biology Textbook has been prescribed as a textbook by the Central Board of Secondary Education for all the higher secondary schools affiliated to the Board from the school year 1964-65. This textbook is being brought out in sections. The following two sections have been brought out and the remaining sections are expected to be ready in August 1965.

(1) Biology:—A Textbook for Higher Secondary Schools:
Section 1—Some Basic Facts About Life—Rs. 2.25.

(2) Biology:—A Textbook for Higher Secondary Schools:
Section 2—The Diversity of Plant Life—Rs. 2.75.

All the sections of the Biology Textbook will be cloth-bound in one volume and the bound copies are expected to be ready during this calendar year.

HINDI TEXTBOOKS

(1) Kavya Sankalan: A collection of selected poems (A Poetry Textbook in Hindi for Higher Secondary Schools)—Rs. 1.85

(2) Gadya Sankalan: A collection of selected essays (A Prose Textbook in Hindi for Higher Secondary Schools)—Rs. 2.15.

These have been prescribed as textbooks by the Central Board of Secondary Education for all the higher secondary schools affiliated to the Board from the school year 1965-66.

FIRST YEAR BOOK OF EDUCATION—A REVIEW OF EDUCATION IN INDIA (1947-1961) (Revised edition in two parts.)

The First Indian Year Book of Education was published by the National Council of Educational Research and Training in August 1961. It was devoted to a review of education in India from 1947 to 1961 and covered the educational development in the Centre and in the States during post-independence period.

In the revised edition under print the facts and figures have been brought up to the end of 1961 In view of the bulk of the publication, this revised edition has been divided into two parts. Part One sets forth a review of education in the whole country and the Union Territories. Part Two which deals with the development of education in the States is expected to be ready before the end of 1965

Workers in the educational field and all those who are interested in Indian education will find it useful

Part One—Pages 418+xxii—Price Rs. 17.00

Copies available from:

The Chief Publication Officer,
National Council of Educational Research and Training, 114-Sundar Nagar
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OR

From Approved Sales Agents.

INSTRUCTIONS TO AUTHORS

School Science is a quarterly journal intended to serve teachers and students in schools with the most recent developments in science and science methodology. It aims to serve as a forum for exchange of experience in science education and science projects.

Articles covering these aims and objectives are invited.

Manuscripts including legends for illustrations, charts, graphs, etc , should be neatly typed, double spaced on uniformly sized paper and sent to the Editor, School Science, Department of Science Education, NCERT, H2/3 Model Town, Delhi-9. Each article may not normally exceed 10 typed pages

The article sent for publication should be exclusive for this journal. Digests of previously published articles modified to suit the scope and purpose of School Science will be accepted. In these cases the name of the journal in which the original article appeared, must be stated.

Please do not underline the headings.

Selected references to literature arranged alphabetically according to the author's names may be given at the end of the article wherever possible. Each reference should contain the name of the author (with initials), the year of publication, the subject title of the publication, the volume and page numbers.

In the text, the reference should be indicated by the author's name followed by the year of publication enclosed in brackets, e g , (Passow, 1962). When the author's name occurs in the text, the year of publication alone need be given in brackets, e.g., Passow (1962).

Illustrations may be limited to the minimum considered necessary, and should be made with pen and indelible Indian ink. Photographs should be on glossy paper, at least of post card size, and should be sent properly packed so as to avoid damage in transit.

Ten off-prints without cover are supplied free to the authors. Extra copies, if required, may be ordered while sending the manuscript, and will have to be paid for by the authors.

Atomic and Other Useful Constants

D. S. Kothari

Chairman, University

Grants Commission, New Delhi

$$\hbar = 1.0545 \times 10^{-27} \text{ erg sec}$$

$$2\pi\hbar \equiv h = 6.6256 \times 10^{-27} \text{ erg sec}$$

$$e = 4.803 \times 10^{-10} \text{ esu}$$

$$c = 2.998 \times 10^{10} \text{ cm/sec}$$

$$m_e = 9.109 \times 10^{-28} \text{ gm}$$

$$k = 1.381 \times 10^{-16} \text{ erg/deg K}$$

$$G = 6.670 \times 10^{-8} \text{ dyn cm}^2/\text{gm}^2$$

Avogadro Constant $= 6.023 \times 10^{23}$ per mole

$$\boxed{m_e = 9.11 \times 10^{-28} \text{ gm} = 0.511 \text{ Mev} = \frac{1}{3.86 \times 10^{-11} \text{ cm}} = \frac{1}{1.29 \times 10^{-21} \text{ sec}}}$$

$$\alpha \equiv \frac{e^2}{\hbar c} = \frac{1}{137.0388} = 7.2972 \times 10^{-3}$$

$$a_0 = \alpha\, ƛ_c = \alpha^2 a_H$$

$$a_H = \frac{\hbar^2}{me^2} = 0.529 \times 10^{-8} \text{ cm}$$

$$ƛ_c = \frac{\hbar}{mc} = 3.861 \times 10^{-11} \text{ cm}$$

$$a_0 = \frac{e^2}{mc^2} = 2.818 \times 10^{-13} \text{ cm}$$

$$m_e c^2 = 2 R_{y\infty}/\alpha^2$$

$$R_{y\infty} = 109,737.3 \text{ cm}^{-1}$$

$$= 13.605 \text{ electron-volt}$$

Fine-structure doublet separation in hydrogen ($p_{1/2}, p_{3/2}$ levels for $n = 2$) $= \frac{R_H}{16}\alpha^2 = 0.366$ cm^{-1}

* For Atomic Constants *see* E.B. Cohen, Table of Physical Constants, *N. Cimento* p. 134; (1957); Also, *Physics Today*, February, 1964.

φ_0 (Thomson scattering cross section) $= \frac{8\pi}{3} a_0^2 = 0.665$ barn

(1 barn $= 10^{-24}$ cm^2)

$\lambda_\pi^2 \sim (1.4 \times 10^{-13})^2 \sim 10^{-26}$ cm^2.

Bohr magneton $\mu_B = 9.273 \times 10^{-21}$ erg/gauss

Bohr nuclear magneton $\mu_N = 0.505 \times 10^{-23}$ erg/gauss

Proton moment $\mu_p = 1.410 \times 10^{-23}$ erg/gauss

Muon moment $= 3.1834\, \mu_p = \frac{m_e}{m_\mu} \mu_B$

De Broglie Wavelength

for electron $\lambda_e = \frac{12.26 \times 10^{-8}}{\sqrt{\text{electron-volt}}} = \frac{7.274}{(\text{velocity})} = \frac{1.552 \times 10^{-19}}{\sqrt{\text{erg}}}$ cm ..(1)

for neutron $\lambda_n = \frac{2.860 \times 10^{-9}}{\sqrt{\text{electron-volt}}} = \frac{3.956 \times 10^{-3}}{(\text{velocity})} = \frac{3.602 \times 10^{-18}}{\sqrt{\text{erg}}}$ cm ...(2)

Photon wavelength $(\lambda) = \frac{12397.7 \times 10^{-8}}{(\text{electron-volt})}$ cm ...(3)

Combining (1) and (3) : $\lambda = \frac{12.26 \times 10^{-8}}{\sqrt{V^*}}$ cm

with $V^* = V + 0.9785 \times 10^{-6} V^2$

Note : (i) Definition of V^* : we have $(eV+mc^2)^2 = p^2 c^2 + m^2 c^4$

or $p = \left(2eVm + \frac{e^2 V^2}{c^2}\right)^{1/2} = \left[2em\left(V + \frac{e}{2mc^2} V^2\right)\right]^{1/2}$

$= [2em\, V^*]^{1/2}$

(ii) $p = \frac{He\rho}{c}$. In the relativistic case $p = eV/300$ c,

$V = 300\, H\rho$.

$H\rho = 3.372 \sqrt{V + 0.9785 \times 10^{-6} V^2}$; H in gauss, V in volt, ρ in cm.

1 atomic mass unit $= 931.48$ MeV

1 g $= 5.610 \times 10^{26}$ MeV

1 electron mass $= 0.511$ MeV

1 proton mass $= 938.211$ MeV

1 neutron mass $= 939.505$ MeV

1 e.v. $= 1.602 \times 10^{-12}$ erg

$E/\tilde{\nu} = hc = 1.986 \times 10^{-16}$ erg cm

The g-factor for free electrons is [*Phys. Rev.* **130**, 847 (1963)]

$$g = 2(1 + a),$$
$$a = \alpha/2\pi - 0.328\, \alpha^2/\pi^2,$$
$$= 0.001{,}159{,}615,$$

as against the experimental value of $\alpha/2\pi - (0.327 \pm 0.005)\ \alpha^2/\pi^2$.

Lamb shift for the s-level ($n=2$) in H-atom is 1060 megacycles/sec $= 4.4 \times 10^{-6}$ ev.

SOME ASTROPHYSICAL CONSTANTS

Schwarzchild Radius

$$2G/c^2 = 1.5 \times 10^{-28}\ \frac{\text{cm}}{\text{gm}}$$

$$\frac{e^2}{Gm^2} = \frac{e^2/mc^2}{Gm/c^2} \sim 10^{12}$$

Hubble Constant H = 10 km/sec. megaparsec.
(1 parsec = 3.26 light years = 3.1×10^{18} cm)

Photometric radius of 'the Universe' = 10^{28} cm

Matter density = 1 atom/cm^3 (galactic)
= 10^{-6} atom/cm^3 (meta-galactic)

Galactic density = 10^{-71}/cm^3

Starlight density = 1 ev/cm^3 (galactic)
= 10^{-3} ev/cm^3 (meta-galactic)

Cosmic ray density = 1 ev/cm^3 (local)

Magnetic Field = 10^{-6} gauss (galactic)
= 10^{-7} gauss (meta-galactic)

Quasi-Stellar Sources (See *Scientific American*, p. 54, Dec. 1963)

('Perhaps the most bizarre and puzzling objects ever observed through a telescope')—some 10 are known. 'Source' 3C-273 is 2 billion light years distant, and about 3000 light years in diameter; (Doppler shift 16 per cent). Mass about 10^8 Solar Masses. Its 'period' is about 13 years.

3C-286 is 2 — 6 billion light years distant.

Energy released: 10^{47} erg/sec or one solar-mass-equivalent in a year

Useful Energy-conversion Relations

1 *kwh* $= 3.412 \times 10^3$ BTU
$= 0.86 \times 10^6$ cal
$= 2.66 \times 10^6$ ft lb

$1\ ft\ lb$	$= 1.356$ joule
$1\ h.p.$	$= 746$ watt
$10^6\ watt\ hr$	$= 3.412 \times 10^6$ BTU
	$= 0.86 \times 10^9$ gm cal
	(= 125 kg of coal
	= 400 kg of lignite
	= 83.3 kg of petrol
	= 94.5 m^3 of natural gas
	= 250 kg ($\approx 0.5\ m^3$) of vegetal fuel
	= 0.04 gm of U 235)

Plants that India gave the World

P. Maheshwari

Head of the Botany Department, Delhi University, Delhi

FOR nearly two thousand years India was a prize for which men worked and warred and greatly adventured. What was it that brought other ships to India's coast, and kept foreigners on our land for several hundred years despite immense distances, the jealousy of other nations, and the restless hostility of the Indians themselves? Predominantly it was the green gold growing on the lap of this country which acted like a magnet in attracting people of different races. The following account deals with only a few selected plants which were in all probability indigenous to the Indo-Malayan region and have spread from here to other parts of the world.

SUGARCANE

In ancient times the only sweetening material known to the Western races was the honey produced by bees from the sugary nectar of flowers. A prosperous land was described as one 'flowing with milk and honey'. When Alexander came to India in 320 B.C. he was surprised to see reeds from which the 'barbarians across the Indus' obtained all the honey they wanted.

According to Hindu mythology, the origin of the sugarcane took place in a rather mysterious way. As the tale goes, King Trishankhu once approached the sage Vishwamitra with the request that he (Vishwamitra) should send him to heaven. Vishwamitra agreed but Indra refused admission. When Trishankhu again appealed to Vishwamitra, the latter created a new heaven *Trishankhu Swarg* (a place between earth and Heaven) for the King. Sugarcane was one of the several plants brought into being for the King's use. Fortunately for us, a mishap resulted in the Trishankhu Swarg being thrown down to the earth along with the sugarcane.

In the eighth century A.D. sugarcane reached Spain and in the fifteenth century it spread to Madeira, the Azores and the Cape Verde islands. The seventeenth century saw sugarcane cultivated throughout the tropical regions of the world. Until about a hundred years ago it was the chief source of sugar, although now the beet is also important. India remains to this day one of the most important cane growing countries of the world.

RICE

Rice is the most important food crop of Asia and at present its cultivation extends to almost all the tropical and subtropical regions of the world. In India and China the cultivation of rice is as old as history and numerous references have been made to it in ancient Hindu scriptures and excavations. The oldest specimens yet known to the world are of carbonized paddy found in the excavations at Hastinapur (Uttar Pradesh) and dating as far back as 1000-750 B.C., but there is no doubt that like wheat it was already in cultivation four thousand years ago.

The Greeks came to know of the crop after Alexander's invasion of India. The

Arab traders, who visited the west coast of India, learnt of it still earlier and introduced it further west.

COTTON

Amongst the curious myths of ancient times the most extravagant and persistent in the West was that of the 'Vegetable Lamb of Tartary'. People conjectured that there were trees bearing fruits, which when ripe and open, produced little lambs, whose soft white fleeces could be used to weave cloth. In the fifth century B.C Herodotus gave testimony that 'India has wild trees that bear fleeces as their fruit and of these the Indians make their clothes'. These trees were none other than cotton, and the soft, white, delicate fleece of 'the Vegetable Lamb' was only the familiar cotton wool.

The earliest written record of cotton is in the *Rig Veda* which is supposed to have been composed fifteen centuries before the Christian era. However, it was in cultivation 5000 years ago in the days of Mohenjodaro and we read of the discovery of bits of cloth made of cotton and preserved by the action of the silver coins they enclosed. The cultivation of cotton, its use for the manufacture of piece-goods and the dyeing and finishing of these fabrics made such a wonderful progress in the Middle Ages that India had a roaring trade in cotton goods not only with the adjoining countries but also with far distant lands through Venice.

Independently of the Indus civilization cotton was also domesticated in South America, since cotton textiles have been found in ancient Peruvian tombs and in the cliff dwellings of south-western United States. However, there is no doubt that Indian cotton came first. The Egyptians at that time made cloth from the fibres of flax and have taken to cotton cultivation only in comparatively recent times.

TEA

The tea plant, a native of Assam and the adjoining areas of Upper Burma, cheers and comforts millions of human beings all over the world. China was the first country to cultivate tea and to appreciate its usefulness as a beverage. India remained ignorant of the treasure bestowed on her by Nature and actually made a start in the cultivation of tea by importing seeds from China, although the plants were growing in her forests all the time!

Tea travelled rather slowly. It was introduced in Japan in 1000 A.D. and in Europe in the later part of the sixteenth century. In the seventeenth century it was sold in Britain at 10 guineas a pound. In 1664 a casket was sent to Queen Catherine, wife of Charles II, and she cherished it so much that tea drinking became quite popular among the dignitaries of England. While India is the largest producer and exporter of tea in the world, the crop is also grown in China, Japan, Indonesia, Ceylon and Formosa in appreciable quantities.

MANGO

A great deal more has been written in praise of the luscious mango than any other fruit. It has been the favourite of Indian poets, the abode of the *koel* and of *Kamadeva*, the God of Love. A mango grove was presented by Amradarika to Buddha as a place of repose. Amir Khusro sang its praises in the 14th century and said that while other fruits are edible only when ripe, the mango is good at every stage of its growth. He called it 'the pride of the garden, the choicest fruit of Hindustan'. George Slocombe, a

British journalist who visited India in 1930, wrote 'The fruit of the Tree in Eden was no sweeter to primeval man than the mango is to an Indian. He eats it with passion He speaks of it in the language of poetry .. A corpulent zamindar, sitting under the shade of a banyan tree in the heat of the day, with a basket of mangoes beside him and a water jar, knows no greater happiness. Even the revolt of his tenants against rents and land revenue can trouble his heart but little in that hour of contemplation and gourmandising.'

Akbar is said to have planted, near Darbhanga, the Lakhbagh—an orchard of a hundred thousand trees—at a time when large orchards were unheard of. The *Aine-e-Akbari* contains a long account of the mango, giving information about the quality and varietal features of the fruit.

Today the mango is one of the most important fruits of south-eastern Asia, and is widely grown in Malaya, Indonesia and the Philippine Islands It succeeds well in Hawaii and is also cultivated in the West Indies and Florida.

BANANA

A large number of varieties of the banana are grown in India, Thailand and Malaya. Unmistakable references to it occur in the Epics of the Pali Buddhist canon of 500–600 B C Another reference (from the *Jataka*, ca 350 B.C.) is of particular interest and the 'fruit as big as a tusk' very probably refers to the 'horn plantain' so named because of its likeness to various animal horns or tusks. The sages of India rested in the shade of the plant and ate its fruit.

The plant, which is easily propagated by its corms, travelled far and wide with migrants from the Asiatic mainland Presumably the Arabs introduced it from India into Palestine and then into Egypt in the seventh century A.D. From the eastern coast of Africa it seems to have spread right across the country, for it was already existant on the west coast when Europeans first visited it in the fifteenth century Apparently it was present throughout the islands of the Pacific before they were known to westerners, and there were several varieties growing in Hawaii when those islands were discovered by Captain Cook in 1778. The banana was introduced into tropical America only in 1516 A D but has since spread so rapidly that now it is the most important banana producing region of the world.

Two reasons for the banana's popularity are its high yield and great nutritive value. It has as much as 22 per cent carbohydrate together with vitamins A and C, all contained in a pulp which is soft, sweet, and pleasantly aromatic. True, it is 'the fruit of wise men'.

PEPPER

Of greater importance than all of these, from the standpoint of the historian, is pepper—a native of Malabar and the forests of Kerala. For ages this was one of the most important articles of trade between India and the West. It was well known to Theophrastus in the fourth century B.C. and to Dioscorides and Pliny. Tribute was levied in pepper when money was scarce and rents were often paid similarly.

Pepper was taken to Europe either through the Persian Gulf, Mesopotamia and Syria, or through the Red Sea and the Gulf of Suez. The Romans levied duty on it at Alexandria in 176 A.D. From here it was re-exported to Venice

and Genoa whose prosperity depended largely on their trade with the Orient. It was to break the Venetian monopoly that the Portuguese wanted to find a sea passage to India. The Dutch followed them like ants after a cube of sugar and then the French and the British, all wanting to have a share in the lucrative trade. For many years the Midas touch of India poured gold into Portugal, Holland and England Today the British have left India and pepper is no longer important, but till recently the Portuguese did not wish to give up some pockets of territories which they called their 'Estado da India'. The history of the Goa problem thus goes back to a period more than 450 years ago when the Portuguese came to India in search of spices It is interesting to note that the era of Portugal's greatest wealth and influence coincided with the period of her profitable monopoly of the spice trade.

Among other economic plants which spread from the Indo-Malayan region to many places in the world, mention may be made of the pigeon-pea (arhar), brinjal, cucumber, jute, hemp, indigo, coconut, ginger, cardamom, nutmeg, turmeric and yam. On the other hand the cashew-nut, chilli, tapioca, potato, tomato, groundnut, pineapple, guava, sweet potato, maize, arrowroot, squash and muskmelon now so common in our markets, are not natives of India and have been introduced from the Americas Plant introduction can thus be of tremendous value to people all over the world.

Radiation Hazards and Protection

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THE past few decades have witnessed unprecedented applications of atomic energy in diverse fields. The pace of advance became particularly rapid after 1946 when reactors became powerful sources for the production of radioisotopes. Radioactive isotopes and ionising radiations are being used extensively in the fields of researches in basic and biological sciences, clinical research, diagnosis and therapy, agriculture and industry. Atomic reactors are already producing power in many parts of the world. Atomic submarines have been on the seas for several years now.

In basic research radioisotopes are used as tracers. While chemically indistinguishable from their normal counterparts, radioisotopes, by virtue of the radiations they emit, can be identified (by suitable instruments like the Geiger counter) and followed in extremely minute amounts. By the use of tracer methodology new insight is being gained on such fundamental questions as the mechanism of photosynthesis in plants, detailed functions of the different parts of the living cell, the way genetic information is stored and transmitted, the dynamics and metabolism of different elements in human beings in health and disease, etc. Radioisotopes are telling us the best ways of utilizing fertilizers and evolving more powerful insecticides by a better understanding of the site and mode of action of drugs.

Some of the most spectacular advances lie in the field of application of radiation to medical sciences. Radiotracers are used as a diagnostic aid in the fields of thyroid diseases, blood diseases, cancer, etc. Radioisotopes and external radiation therapy with radio-cobalt units have brought a great deal of benefit to cancer patients.

In industry radioisotopes are used for control of quality in manufacturing processes such as for control of thickness in the paper industry. In America the annual savings to industry by the use of radioisotopes is estimated to be about a thousand million dollars.

Nuclear energy is being harnessed for power production in many countries. We in India are particularly interested in the field because of our desire for rapid industrialization as well as our large reserves of nuclear fuels.

It is apparent that radiation has proved to be a versatile and powerful, almost indispensable, tool in many a field. But there are potential hazards associated with the improper use of radiation, since excessive exposure of the human body to radiation can cause harmful biological effects. It therefore becomes necessary to

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understand these hazards, evaluate them and control them, to assure that we obtain the best use out of radiation and maintain progress.

Radiation Hazards

Our knowledge of the biological effects of radiation has been built up over the past 50 years through human experience in the following fields:

- Early x-ray workers,
- luminous dial painters;
- patients who had been administered radium salts;
- uranium miners,
- atomic bomb survivors in Japan;
- patients receiving high doses during radiation treatment;
- victims of reactor accidents, and
- children whose mothers received radiation exposure during pregnancy.

It must however be emphasized that human experience in this field is rather limited and that for the greater part we have to rely on results of animal experiments.

The actual effects depend on a variety of factors, the most important among which are the total radiation dose, the time period over which the dose is spread, nature of the radiations and part of the body exposed.

The first step in the interaction of radiation with tissues is the ionisation (knocking out of electrons) of a very small number of atoms and molecules constituting the cells of the part exposed to radiation. This initiates a sequence of complex biochemical events which may lead ultimately to cell damage or cell death

Radiation hazards may be external or internal. The external hazard arises from the exposure of the body to penetrating radiations (like gamma rays or neutrons) from sources outside the body. Alpha ray emitters are not an external hazard since alpha rays cannot penetrate even a fraction of a millimetre in tissue. Beta rays will not normally be a significant external hazard since clothing will stop a large part; but beta emitters in contact with the skin can produce loss of hair and skin burns.

Internal hazards originate through the incorporation into the body of radioactive materials. This may arise through inhalation of radioactive dusts and vapours, from ingestion (through eating and drinking) of active materials, or by injection through cuts and wounds. Depending upon the nature of the radioisotope, the radiation it emits, its half-life, etc., even extremely minute amounts of internally deposited radioisotopes may be hazardous. Thus a 'body burden' of more than about one-tenth of a microgramme of radium may lead in the long run to ill-effects. This arises because, once radium gains entry into the body, it gets lodged in the bone where it stays for many decades. Inside the bone, radium and its daughter products give off radiations (alpha, beta, gamma) which can damage vital parts like the bone and blood-forming organs.

The biological effects depend on the part of the body exposed. Some organs like blood-forming organs, reproductive organs and the gastro-intestinal tract are particularly radiosensitive. Whole body exposure is the most hazardous.

The effects also depend on the rate at which the radiation dose is received. 'Acute' exposure (received over a short

period) is more injurious than protracted or 'chronic' exposure. This is because cells have a certain capacity for repair and recovery from the effects of radiation injury. Thus a whole body dose of 600 rem* would be lethal if received as a single exposure. The same dose spread over a period of 20 years should not cause any recognisable clinical effects.

Biological effects can also be classified as *somatic* and *genetic*. Somatic effects are manifested in the person exposed to radiation. They may be manifested soon after exposure (within a few days) while certain types of somatic effects may be exhibited after a latent period of several years. Genetic injury does not affect the exposed persons but the progeny. The exposure to radiation of the sex cells of a person damages the genetic material causing 'gene mutations'. During procreation one of the damaged sex cells may take part in the fertilization process, the fertilized cell, therefore, carrying the defect and repeating itself during successive divisions, leading to an offspring that carries these defective cells.

The early effects of acute whole body exposure (which may occur in reactor accidents or nuclear war) depend on the dose received. For doses less than 50 rem no symptoms will be manifested. For a dose of 50-200 rem, a small percentage of the people exposed may vomit, within a day, some may feel weakness; there will be a temporary decrease in blood counts. No deaths are expected. For 200-450 rem, practically everyone exposed will have radiation sickness. They will vomit soon after exposure, will be sick for a few days, then be apparently well for 1-3 weeks and at the end of this period show epilation followed by moderately severe illness. At 450 rem about half the number of persons exposed will die. In other words, a person exposed to 450 rem has a 50-50 chance of survival. With increasing doses the sickness becomes more acute and for a dose of 600 rem the chance of survival is very small.

Acute local exposure of the skin will lead to loss of hair (dose of 200 rem) and radiation burns. After very high doses burns may not heal and may turn cancerous after a long period of delay.

Late somatic effects can occur after either acute or chronic exposure and may be manifested many months or years after the onset of exposure. The late effects include life-shortening, cataract, sterility, cancer, and in case of foetal irradiation, developmental defects. None of these effects is caused uniquely by radiation, but occur naturally also in the human population. All that can be said is that radiation exposure increases the incidence of these effects. The greater the dose that a person has received, the greater is the chance that he may exhibit one of these defects. The exact correlation of the incidence of late effects with the dose is still uncertain. For the same total dose received, whether the incidence is less for chronic than for acute exposure, and whether there is any threshold dose above which only the effects are manifested are not yet established. To err on the safe side, it is generally assumed that there is no threshold, that the probability of a particular effect is proportional to the total dose received and independent of the dose rate.

As mentioned earlier, the genetic injury

*The *rem* is the unit in which radiation dose is expressed. The *roentgen* is another unit commonly used.

does not affect the exposed individuals but can be inferred only by statistical studies of their descendants. The effects of genetic injury are (i) change in sex ratio (ratio of male to female births), (ii) increased incidence of abortions and stillbirths, (iii) increased incidence of malformed babies, and (iv) increased incidence of infant mortality. For genetic effects, it is generally accepted that there is no threshold dose and that the most significant factor is the total dose accumulated by the reproductive organs up to the time of procreation.

Radiation Hazards in Perspective

All facets of human advance have always had associated with them an element of hazard. The use of fire, electricity and means of transport are examples that come immediately to our minds. Just because there are so many road accidents we have not banned the use of the motor car. Because there have been adverse reactions and even death in certain cases by the use of penicillin and other drugs, we have not prohibited their use. A small dose of morphia can be used to alleviate pain; a larger dose of the same kills. Radiation is no different from any of these. Wisdom lies in the controlled and judicious use of these tools which are double-edged weapons. We may also recall that man has always been subjected to a certain amount of natural background radiation, from cosmic rays, radioactivity in rock, soil and building materials as well as radioactive elements present in minute amounts in the body.

Barring the few exceptional cases like reactor accidents, the exposure situation of greatest practical significance is low level chronic exposure. As mentioned earlier, there is unfortunately little direct information on the biological effects of such exposure. We have to extrapolate from the results of animal experiments at somewhat higher doses.

The International Commission on Radiological Protection which consists of 12 experts in the field drawn from all over the world, makes recommendations from time to time of the 'permissible limits of radiation exposure'. The permissible dose is one 'which is not unacceptable to the individual and the population at large, and which in the light of present knowledge carries a negligible probability of severe somatic or genetic injuries. Further it is such a dose, that any effects that ensue are more frequently limited to those of a minor nature that would not be considered unacceptable by the exposed individual and by competent medical authorities.' The philosophy of radiation protection can therefore be summarised as the taking of a calculated, controllable, small risk.

The presently recommended maximum permissible whole body dose for radiation workers can be basically taken to be 5 rem per year (or 100 mrem per week). The restrictions on the maximum permissible doses for a member of the general public are more stringent.

Control of Radiation Hazards

'Health Physics' is the new science of the protection of radiation workers by the application of the knowledge and practice of the principles of physics, and enables us to reap the benefits of radiation while simultaneously assuring a high standard of radiation safety.

The Institute of Nuclear Medicine and Allied Sciences, located at Delhi under the Research and Development Organisation of the Ministry of Defence, is

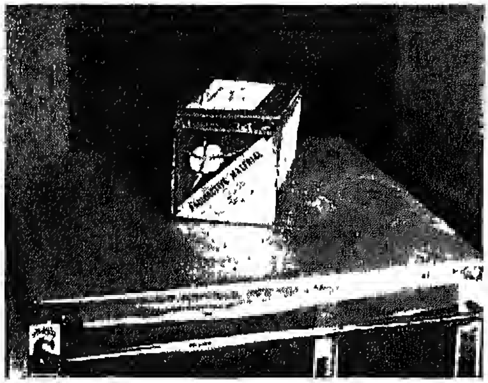


Fig 1 Radioactive isotopes are received from the Atomic Energy Establishment, Trombay in suitably packed containers with distinctive labels The parcels are opened behind protective shielding by trained personnel

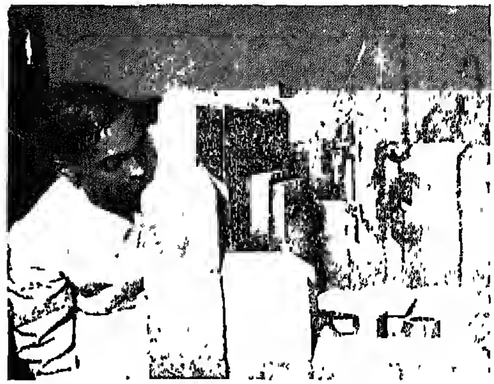


Fig. 2. Radioactive solutions being dispensed by remote control pipette behind lead shielding The worker is viewing the operation through lead glass which protects the eyes from the flux of radiation

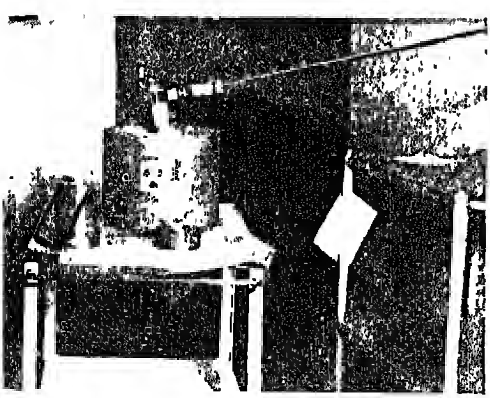


Fig 3 A large activity source being transferred by remote control tongs to be stored inside a lead castle

Fig. 4 Isotopes emanating radiotoxic vapours leading to inhalation hazards are being handled inside a glove box

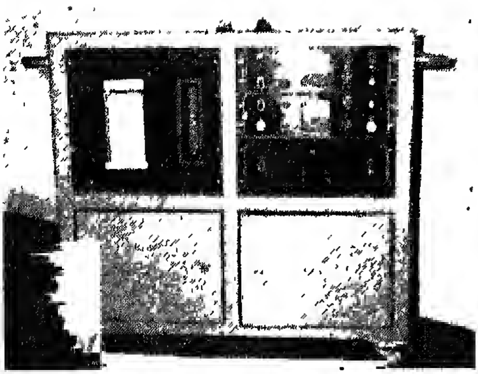


Fig. 5 The Air Monitor is used to monitor and measure the radio activity content of the air in and around the hot laboratory and other areas.

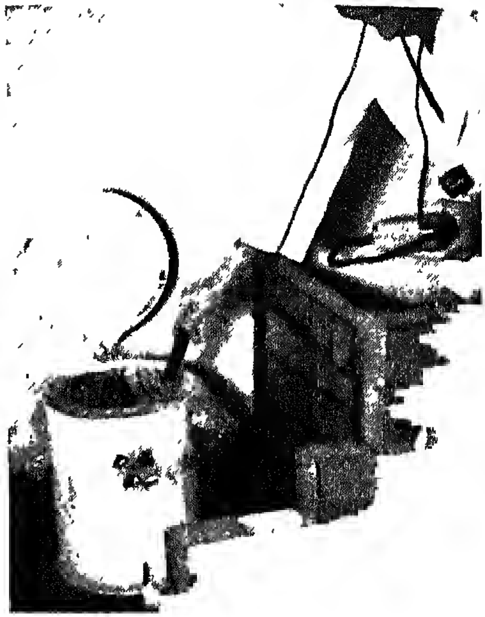


Fig. 6. High level radioactive wastes kept behind protective shielding being monitored for activity level. When level comes down to acceptable values, proper disposal under health physics supervision is carried out.

Fig. 7. Carcass of a rat that had been used in radioactive experiment studies being monitored decide on suitable method of disposal.

Fig. 8. Workers are monitored when leaving the Isotope Laboratory to ensure that they do not carry any contamination on their person or clothing. In case of an accidental contamination, proper decontamination measures are carried out.

concerned with the use of radioisotopes and ionising radiations for clinical research, diagnosis and therapy, as well as for research in allied sciences The Institute has a 'hot laboratory' designed for safe working with high levels of radioactivity. A brief description of the working of the hot laboratory will give an idea of how health physics is put into practice and radiation protection achieved

The Institute's hot laboratory consists of a set of four rooms located in an isolated wing in the first floor of the Institute plus a 'hot animal house' located in the ground floor Facilities are available in the hot laboratory for storage and dispensing of radioisotopes, storage of high level radioactive wastes, radiochemical work, animal experimentation studies with radioisotopes as well as wash and decontamination. Entry to the hot area is through an enclosed corridor.

External radiation hazards are controlled by (*i*) working for minimum necessary time with radiation sources, (*ii*) keeping sufficient distance between the source and operator and (*iii*) interposing sufficient shielding between the source and worker so as to attenuate the flux of radiation Internal hazards are controlled by (*i*) rigorous discipline and clean working habits, and (*ii*) strict control of radio-contamination of working surfaces, laboratory areas of persons (especially hands of workers) which leads to ingestion and inhalation hazards.

Radiation workers wear a 'film badge' for recording the radiation doses received by them. The film badge consists of a small piece of photographic film specially sensitive to nuclear radiations wrapped inside a dark paper and enclosed within a plastic 'casette'. This is worn on the chest for a definite period (generally a week or a fortnight) while working with radiation sources. At the end of the period the film is developed and the degree of blackening gives an indication of the dose received.

Hot Laboratory Discipline

Special protective clothing (generally laboratory overcoats, special shoes, gloves) are worn while working in the hot laboratory After each operation and at the end of the day's work he removes his protective clothing in a prescribed manner, washes his hands and is monitored with suitable instruments (like Geiger counter) for signs of contamination on his person and clothing. Where necessary suitable decontamination procedures are adopted to ensure that he does not carry any radioactivity on his person or clothing. Certain other precautions like avoiding eating, drinking or smoking in active areas are also enforced on the worker. Suitable shielding (usually of lead) and remote control equipment are available to reduce the external radiation dose to workers; lead glass provides protection to the eyes

Special attention has been given to the pattern of furnishing the hot laboratory to ensure radiation safety and contamination control. Metallic tables and stools with high grade stainless steel tops are used instead of wooden furniture, so that in the event of an accidental spill, the surface can easily be decontaminated. Foot-operated dust bins, taps and sinks are provided so that they can be used even when the hands are contaminated. Operations involving radioactive liquids are carried out inside trays lined with blotting paper so that in the event of an

accidental spill, the spill is confined to the tray and is not allowed to spread

Glove boxes are available for operations which may lead to the formation of radioactive vapours, dusts or aerosols. Manipulations are carried out inside the glove box by the use of rubber gloves; the glove box is maintained at a slightly negative pressure by means of a small motor located inside. This ensures that air will flow only from outside into the glove box and not vice versa. The exhausted air is filtered and discharged through an outlet situated at a sufficient height to ensure a harmless dispersal into the atmosphere of radioactive vapours

A washing machine is available for washing contaminated clothing, which are not allowed to go to the normal laundry. A separate vacuum cleaner is used for cleaning the hot area to avoid raising of dust as with normal operations.

Regular radiation surveys of working areas as well as monitoring of radioactivity levels in air, water and sewage are carried out to ensure that at no stage are the levels allowed to exceed permissible values. Records are maintained of the arrival, storage, dispensing, use and disposal of radioactive materials, as well as personnel, area, air and water monitoring results. Special care is taken regarding the disposal of radioactive wastes (including the carcases of animals used in radioactive experiments) which is done under the supervision of the health physicist.

Visitors are not normally allowed into the hot area. Rules for working in the hot laboratory, procedures to be adopted in the event of an accident as well as the persons to be contacted in any emergency are prominently displayed

Great care is taken in the selection of radiation workers. They must be both physically and mentally suited for this type of work. They must have motivation and interest, clean working habits and a high sense of responsibility. They must have sufficient understanding of radiation hazards and their control. For this purpose every entrant to the Institute undergoes a preliminary orientation course on potential hazards of radiation, maintenance of radiation safety and operation of nuclear electronic instruments for the detection and measurement of radiation.

By strict observance of radiation safety discipline at all levels of workers at the hot laboratory, it has been possible to keep the radiation exposure situation extremely satisfactory. For instance, in 1963 the average dose per worker per week was 0.06 mrem (as against the 100 mrem/week allowed by the International Commission on Radiological Protection). The radiation workers also undergo periodical medical check-ups

It is indeed fortunate that right in the early stages of the development of radiation as a versatile tool in man's hands, we have come to recognise the potential hazards associated with the misuse of this tool, and developed the techniques for controlling it and using it judiciously for human advancement.

World Biology Project Takes Shape

Nigel Calder

On 25 July in Paris, the International Biological Programme—'the biologists' IGY' became a definite project when leading scientists agreed on its scope and planning. Full-scale work may begin in 1967 and will yield basic information about biological productivity and human life in many regions.

WHEN the Special Committee for the International Biological Programme came into being it was hard to grasp that we were witnessing the beginning of what should be one of the great scientific adventures of our day, full of promise for human welfare. The hot weather in Paris last week-end perhaps contributed; every one may have been weary from the preceding days of working parties; the distinguished scientists from 32 countries were subdued, perhaps, by the scale of the task they were setting themselves; may be biologists are simply more modest than the physicists who, a decade ago, were planning the International Geophysical Year like men plotting to take over the world. Whatever the reasons, SCIBP (pronounced 'skip') was formally constituted on 25 July in a relaxed atmosphere which a casual observer might have mistaken for indifference.

Not until right at the end, when Professor Jean Baer of Switzerland made his first speech as the newly elected president of SCIBP, was there a sense of occasion. He spoke in positive terms of the work that lay ahead.

There is nothing to be indifferent about in the concept of the International Biological Programme. Four or five years ago it was, to be sure, a programme in search of a theme—the vague idea of a small group of biologists that, if the physicists could have their IGY and achieve so much scope in a project whose direct benefit to mankind was obscure, why should not the biologists organise something similar and more relevant to the pressing problems of feeding the exploding populations of the world? It is only now that the topics and character of the research have been decided, after long and sometimes controversial discussions on the panels of the planning committee and among interested scientists in many countries. The plan that emerges is one which will fill remarkable gaps in our knowledge of life on our planet and our own species.

With its theme of 'The biological basis of productivity and human welfare' it will be of great practical consequence, even though most of the researches proposed are 'pure' in character. It will give new orientations to field biology and, like the IGY, it will provide comparative, quantitative data from many parts of the world.

Professor C. H. Waddington wrote, during the earlier planning phase, in *New Scientist* (Vol. 18, p. 248):

All the major civilisations throughout history have lived in landscapes moulded

Reprinted from New Scientist, 23 (402): 260-262, July 30, 1964 with the kind permission of the editor.

by human activity into systems which harness, more or less efficiently, the inherent biological productive capacity of their territory to serve the demands of the human population. One of the most basic tasks over much of the earth's surface today, in the 'developing countries', is that of remaking the landscape into a more productive form. This not only requires detailed know-how in agricultural and other techniques, but should be based on a knowledge of the *underlying factors which define or limit the potential biological productivity of the various regions* (*italics mine*).

The most obvious objection to a formally organised, world-wide study of these 'underlying factors' is that all the ecologists, marine biologists, and so on, who are qualified to undertake this work are already busy at it. To try to coordinate their activities or mobilise them in a common programme might seem officious and even liable to stifle scientific initiative. The answer to this objection is that many years may pass before random research fills in some of the obvious gaps in knowledge; or before modern numerical and comparative biological methods are extended to places and circumstances that vitally need them.

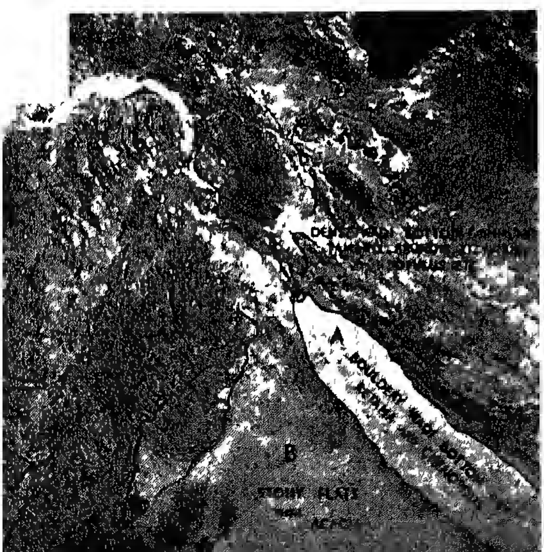
What are these gaps and what can the IBP do about them? Let me mention some of the areas of ignorance identified by the planners. Itemised, they provide a startling reflection of the priorities of science up till now.

What we do not know—As Dr. P.J. Newbould has pointed out, there is a fifty-fold discrepancy in the utilisation of the energy of sunlight growing plants, between a good field crop (10 per cent of the visible radiation being used) and the average global efficiency (0.2 per cent). Our knowledge of how this primary conversion efficiency, on which all life depends, varies according to the plant species and where they grow, is fragmentary. How factors such as soil, climate and human intervention affect productivity is known in some detail in certain localities, but there are whole regions where measurements have been few or inadequate, whether we are concerned with a 'wild' near natural forest community or an intensive farming sector. The productivity of near natural communities created by evolution provides a basis for assessing man's agricultural performance in similar environments. But such unmodified sites are being rapidly lost, so that there is an urgent need both for measuring their productivity and determining factors and for preserving selected sites in all regions as 'outdoor laboratories' for the scientists of the future.

Biologists have been aware for a long time of two basic processes of life whereby gases of the air are made available for plant growth. Photosynthesis is one: sunlight absorbed by the green chlorophyll of leaves serves to make carbon dioxide and water react to form simple organic compounds that are elaborated into the tissues of the plants. Nitrogen fixation is the other, natural 'fertilising' process carried out by bacteria in the soil and in plant nodules. We do not know in much detail how far the efficiency of photosynthesis is determined in various organisms, by genetic and physiological factors on the one hand or by environmental factors on the other. In the case of nitrogen fixation, we do not even know precisely what species of organisms are responsible for it in many parts of the

world, or whether we can enhance this natural fertilisation of the soils by inoculations of suitable bacteria.

Life in the fresh water and sea water of the world presents us with a different pattern of ignorance. Here research is already pretty thorough, although too small in scale in comparison with the vast areas of rivers, lakes and oceans to be studied There is, in the case of inland water, a need to compare more systematically the productivity and metabolism of running and still water in the main climatic regions of the world (the south temperate zone, for example, deserves more attention), to relate biological studies to the problems of world water supplies, and to coordinate international research on the marine fishes that swim up the rivers to spawn (notably those of the North Pacific, which breed in Japan, the USSR, Canada and the USA). Freshwater systems and their interactions with the surrounding lands may be particularly suitable for study with the aid of computer models. The practical opportunities for farming ponds and rivers are immense.



An aerial photograph of part of Jordan with notes of vegetation and range types. Aerial photographs may provide a rapid method of broadly classifying ecological systems during the International Biological programme.

The marine biologists are busily assessing the potential production of protein from the oceans, and were well organised internationally before the IBP came along. However, the IBP preparations have focussed attention on the need for urgent investigations of life in those waters most accessible to fishermen of the developing countries—mangrove swamps, lagoons, estuaries, coastal waters and the regions of the continental shelf

Perhaps the most notable area of present ignorance concerns man himself and his many adaptations to different environments. In many important respects, we know more about some of the lower animals than we do about human beings. What are the patterns of tolerance to cold, for example, in Eskimos and Negroes? What happens to the individual's response to cold, when a Texan becomes a lumberjack in the Canadian north or an Indian installs air-conditioning in his home? When European Jews go to live in Israel, how do they adapt to the hot climate? Are the ethnic groups who live high in the Andes or the Himalayas physiologically fitter for their environment—in matters of respiration, blood, physique and work capacity—than, say, visiting mountaineers?

Apart from these adaptations to extreme conditions of cold, heat and altitude, there is a striking lack of information about fitness, growth and physique in most human populations. How does capacity for work vary with age and sex for example, among subsistence farmers who can barely scrape a living? What happens to people of different ethnic groups when they exchange a vigorous life for office work? How does an Olympic athlete differ from his fellow countrymen? Among the children of the

world, can we define the connections between nutrition, environment and ethnic groupings on the one hand and growth, age of adolescence and scholastic achievement on the other?

Another, related set of questions concerns human heredity. Blood group patterns and other easily determined characters vary from place to place and from one ethnic group to another, providing a rough picture of human genetics in action and of how populations are changing. Selected communities can be studied in more detail to show the influence of heredity on disease and fertility and what the effects are of isolation and inbreeding, and of racial intermarriage. We do not yet understand how many of the human genetic characters in various parts of the world have been influenced by pressures of natural selection.

What happens to people of primitive tribe when they become "modernised" like this Australian aborigine at work in a garage in South Australia

Finally, within the scope of the IBP there are important but neglected topics in applied biology in which basic international research could prompt practical action. In particular, there are productive plants and animals whose use for human purposes has scarcely been considered. For example, the rich Mediterranean flora may contain plant species of value in similar climatic conditions in Australia or Latin America. Even more exciting are the scarcely used species of the rain forests, which might provide new cultivated plants, and the possibilities of adapting plants from one type of climatic region to another. With such aims in mind, there must be careful studies of the plants in their natural environments, and perhaps bio-engineering to help in converting new crops into human food. Other needed research of direct practical value includes the international tracking of air-borne spores and pests.

How to find the answers. I hope I have now shown how wide and promising, and yet down to earth, is the a la carte offered to the world's biologists by the IBP. It will, of course, be clear that the programme emphasises field biology, rather than the laboratory investigations that represent the mainstream of present-day biology. But that does not mean advanced techniques and sophisticated approaches are not required. On the contrary, with its emphasis on ecological research 'in depth' at selected sites in the main regions of the world the IBP will encourage the study of living communities as complex systems to become an exact, rather than a descriptive science. It also provides opportunities of collaboration between biologists and non-biologists to extend the analysis from geology and climate at one end of the scale to elaborate human societies and

economies at the other. Meteorologists, soil scientists and social scientists may all have a part to play, as well as workers in the many sub-divisions of biology.

A gestation of two or three years is envisaged for the IBP. Some participants think this period is too short, in view of all the planning and preparation required, including agreement on standardised techniques of measurement (some of which may require instruments still to be perfected), training field workers and writing manuals of procedure. Considerable funds—perhaps half a million dollars—will have to be found for the preparatory work. Thereafter, each country will make such contribution as its biologists can arrange and obtain funds for; field biology being an inherently 'slower' science than geophysics, the main part of the programme is to last about five years, compared with 18 months for the IGY and two years for the present Quiet Sun Years.

The work of SCIBP is broken down into technical sections, as follows:

A. Terrestrial productivity
   1. Ecology
   2. Physiology.
   3. Conservation.
B. Freshwater ecology.
C. Marine productivity.
D. Human adaptability.
E. Use of biological resources.

Other groups are concerned with training and public relations and with administration and finance.

The approach and nature of the programme varies according to the subject matter and the activities of pre-existing organisations and laboratories Attempts are being made to devise 'minimum' programme of necessarily superficial measurements, with the limited resources of the less-developed countries in mind, and much more elaborate research 'in depth' for the better provided countries. It is expected that the developed countries will mount substantial expeditions to the network of sites selected for detailed study.

A note of warning—The IBP is magnificent, on paper. It may be over-ambitious in concept and timing, but no one can deny the need for the information it will provide. Nevertheless, the aims and procedures of the programme have still to be 'sold' to the many biologists around the world who will have to do the work and are already presumably fully engaged. The scientific case for the programme, and the instruments and techniques which should be employed, are by no means as self-evident as in the case of the IGY. So, great leadership will be required from the officers and members of SCIBP if their venture is to be, in the outcome, as fruitful as it deserves to be. In particular, it is going to be hard to recruit sufficient taxonomists for identifying the many species involved in the complex communities. Much of the responsibility will fall on Professor Baer (former President of International Union for the Conservation of Nature and Natural Resources), the programme's scientific director, Dr E.B. Worthington and the four vice-presidents who join them in the Bureau of SCIBP - Professor Stanley A. Cain of the United States, Professor C.H. Waddington of Britain, Dr. K. Petrusewicz of Poland and Professor G. Montalenti of Italy.

Governments and grant-giving organisations will also have to be persuaded of the need to support the preparation of the IBP and its implementation. The biologists will have to be a good deal less meek in such matters than they usually are, to get their way.

This Year's Nobel Laureates in Science*

R. K. Datta
University College of Science & Technology, Calcutta

ALFRED NOBEL, Swedish engineer and chemist, who invented explosive dynamite, gave bulk of his wealth to establish a prize fund. From the interest of this fund Nobel Prizes are annually awarded to persons who have rendered to humanity the greatest services during preceeding years. Five annual awards are made for outstanding contributions or discoveries in peace, literature, physics, chemistry, and physiology or medicine. The awards for 1964 in science subjects were announced and the prizes were presented in Stockholm on December 10, 1964.

Physics

This Nobel Prize in Physics has been awarded jointly to Prof. Charles Hard Townes of the Massachusetts Institute of Technology, U.S.A., and Prof. Nikolai Basov and Prof. Alexander Prochorov of Lebedev Institute, Moscow, U.S.S.R. for their work in developing the Maser-Laser apparatus which throws light into an intense beam capable of cutting metal and performing knifeless surgery.

Prof. Townes who is the University Professor of Physics at the Massachusetts Institute of Technology was born in South Carolina, U.S.A. in 1915. He was educated at Furman University, Duke University and California Institute of Technology. He served as a member of technical staff of Bell Telephone Laboratories, New York (1939-48), Associate Professor of Physics at Columbia University (1948-50), Professor, Executive Officer and Director of various departments and laboratories there (1950-56). Prof. Townes was also the Director of the Research Institute for Defence Analyses, Washington. Since 1961 he is the Professor of Physics and Administrator at the Massachusetts Institute of Technology. He taught as a visiting professor of physics at the universities of Paris (1955-56) and Tokyo (1956). He received the honorary D. Litt. degree of Furman University in 1960. As a consultant he is also associated with National Bureau of Standards and Brookhaven National Laboratory. Prof. Townes is a co-author of a book entitled *Microwave Spectroscopy*. He holds many patents on various electronic devices. His work since World War II in electronic physics particularly in radio astronomy, microwave spectroscopy, atomic clocks and theory of relativity has been very outstanding scientific accomplishments. He conceived the idea of developing an instrument to measure time more absolutely and irrespective of the motions of the sun and stars. He called this device a MASER, from the initials of its description, microwave amplification by stimulated emission of radiation. This device has put the world on an exact schedule without consideration of the seasonal variations in the rate of rotation and the normal slowing down and speeding up of

*Refers to 1964

the yearly revolution of the earth. An important extension of MASER has been the development of the LASER (light amplification by stimulated emission of radiation). These continuous beams of light have been used to improve methods of radio and television transmission, to maintain telephone conversation without wires, and to perform knifeless surgery. In May 1962 scientists used LASER to flash a beam on the moon, the first time man illuminated another celestial body.

Chemistry

Dr. Dorothy Hodgkin (nee Crowfoot), Wolfson Research Professor of The Royal Society, London, since 1960, who has been awarded this year's Nobel Prize in Chemistry for her outstanding contribution in respect of varied application of X-Ray crystallography in the elucidation of structures of complex organic molecules and specially of vitamin B_{12} or cyanocobalamin, was born in 1910. She had her education at Sir John Leman School, Beccles, and Somerville College, Oxford. She received the honorary degree of D.Sc. from the Universities of Leeds and Cambridge. She became a fellow of the Royal Society, London in 1947 and received the Royal Society Medal in 1957. She is associated with the University of Oxford as a Reader in X-ray crystallography.

The isolation from liver of a red crystalline compound having therapeutic activity in the treatment of pernicious anaemia was announced in 1948 by investigators in the U.S.A. and U.K. The compound, previously known as anti-pernicious anaemia factor, is now called vitamin B or cyanocobalamin, the latter nomenclature being based on the presence in the molecule of a cyanide ion in co-ordinate linkage with a cobalt atom. Through a systematic chemical degradation and X-ray crystallographic studies carried out by Dr. Hodgkin and her associates the complex structure of this vitamin has been elucidated. Dr. Hodgkin, by X-ray analysis of salts of penicillin, showed the presence of a beta-lactam ring in this antibiotic. Similarly she contributed much towards the confirmation of the structures of vitamin D, stilbestrol and hexostrol.

Physiology and Medicine

The Nobel Prize in Physiology and Medicine has been awarded jointly to Prof. Konrad Bloch of the Harvard University U.S.A. and Prof. Feodor Lynen of the Institute fur Zellchemie an der Deutschen Forschungsanstalt fur Psychiatrie (Max-Planck-Institut), Munich, Germany, for their outstanding demonstration of the pathways of cholesterol biosynthesis and fatty acid oxidation respectively.

Prof. Bloch, Higgins Professor of Biochemistry at the Harvard University, was born in 1912 at Neiss in Germany. He studied Chemistry at Technische Hochschule at Munich. In 1936 he left Germany and went to the United States. He joined the Columbia University and obtained the Ph.D. degree in Biochemistry (1938). He served there as an instructor and research associate in Biochemistry (1941-46). Next Dr. Bloch joined the University of Chicago as Assistant Professor of Biochemistry and later became its Professor. Since 1954 he is at the Harvard University. Cholesterol is a fat-like substance found in all animal fats and oils, and in many tissues of the human

body. Dr. Bloch demonstrated that this substance is formed within the body from smaller substances. Carbon atoms of acetate molecules are used as building materials for the complex cholesterol molecule. The transformation of acetate into cholesterol molecule takes place in stages in the body. According to the findings of Dr. Bloch the pathways of biosynthesis of cholesterol may be visualised as: Acetate→(isoprenoid units)→squalene→lanosterol→zymosterol→cholesterol. The credit of Dr. Bloch lies in revealing the whole sequence of events in the biosynthetic mechanism of cholesterol in animal and human bodies. Among other remarkable contributions mention may be made of his demonstration of the conversions of cholesterol into bile cholic acid and into pregnandediol, a female sex hormone. He also added significantly towards the understanding of the biosynthesis of fatty acids in animal fats from smaller molecules.

Fats and oils are chemically made up of fatty acids and glycerol into which the ingested fats and oils are broken down in the intestine. Biological fatty acids have usually straight chains and an even number of carbon atoms ranging from four to eighteen. Tissues in general break fatty acids down to two-carbon units by a process known as beta-oxidation. This break-down process has been shown by Dr. Lynen along with others to take place in steps. He proposed a scheme called fatty acid cycle or spiral involving the role of an important biochemical known as coenzyme A. According to Dr. Lynen's scheme the fatty acid first forms a coenzyme A-derivative and thereupon liberates a two two-carbon unit and forms an acid derivative with two carbon atoms less than the starting fatty acid. This shorter fatty acid chain immediately undergoes the same break-down sequence in a second cycle, again liberating a two-carbon unit and so on. The two-carbon units are finally broken and changed to carbon dioxide. The break-down of fatty acids through these processes provides energy to the body. The synthesis of fatty acid chain from smaller units, Dr. Lynen indicated, takes place by the reversal of the break-down process.

The Earth and the Apple

V.V. Narlikar
Chairman, Rajasthan Public Service Commission, Ajmer

THE mathematician, W. Bolyai, expressed the wish that an apple tree should stand over his grave. not on account of the apples of Eve and Paris which made hell out of earth but on account of that of Newton which elevated the earth to heaven.

According to the historian, F. Cajori, this was said in the 19th century. Newton's apple is very much in the minds of physicists once again and very much in the press now

It was Newton's genius to connect up logically farflung matters like the fall of an apple to the earth with the motion of the earth about the sun and of the moon about the earth. It matters very little whether the celebrated apple actually existed or not in material form, and whether it was seen to be falling by Newton in his village in 1665 or 1666.

In the story of the apple and the earth as told by Newton, we have the earth as of mass m and the apple as of mass m^1 and we have also the constant of gravitation G. According to Newton's law of universal gravitation each was attracted by the other with the force $F=mm^1\ G/r^2$ where r is the distance between the apple and the earth. When Newton was asked by scoffers and doubters how this miracle of attraction occurred he gave the celebrated answer *hypotheses non fingo* meaning thereby that he did not deal in conjectures.

The mouths of the scoffers and doubters were stopped by the extraordinary success that Newton's theory achieved in predicting the motions of comets, planets and the other celestial bodies of the solar system.

In the 20th century the doubts reared their ugly heads again. Einstein's theory of gravitation was born in 1915. In the new story of gravitation as revised by Einstein the old friends m, m^1 and G appear intact. But the absolute space and time are replaced by a new framework of curved space and time and the field laws of here-thus-now relations replace the miraculous distant action of Newton's theory.

At the outset the theory achieved tremendous success but soon inner imperfections were discovered which could not be removed in spite of the best efforts of Einstein and other relativists.

And now, in 1964, when Hoyle and Narlikar** were busy with the problem of the arrow of time in electrodynamics and cosmology, the problem of Mach's principle and the steady state theory and the problem of gravitational collapse in quasars and the C-fields, they saw gravitation in a new light.

Why Newton and Einstein had failed to achieve their objectives was that they

Summary of the lecture delivered by V.V. Narlikar at the Regional College of Education, Ajmer on 18-8-1964

**J.V. Narlikar (See SCHOOL SCIENCE 3 (4): December, 1964)

had taken m as the intrinsic property of the earth and m^1 as the intrinsic property of the apple and G as an empirical constant. Following Mach's philosophy and reinterpreting the significance of Foucault's pendulum on the background of the stars, Hoyle and Narlikar were able to show how the earth and the apple owe their masses to the rest of the universe and how from the principle of stationary action applied in this connection not only equations more general than Einstein's are obtained but the salient imperfections in Einstein's theory are removed. The constant G itself with the appropriate sign is derived.

Thus we have now the latest version of the story of the earth and the apple. You can no longer divorce the earth and the apple from the rest of the universe.

Science Clubs in Kaira District

J. J. Patel

Coordinator, Extension Services, Secondary Teachers College, Vallabh Vidyanagar, Anand

THE pace of scientific progress is very rapid and the young student of today and the teacher have to adjust themselves as quickly as possible. The crowded syllabi and the formal atmosphere in the classroom hardly provide the opportunity for that creative thinking which alone will make for progress and new discoveries.

To supplement this shortcoming of the science syllabus Science Club movement was initiated in the country. The creative activities of the science club would provide enough experiences to the pupil and equip him for a better living in the society.

Schools of Kaira District are awake on this front and a number of schools have started Science Clubs. It was thought worthwhile to take stock of things as they are, so that, the hardships experienced may be overcome, requirements be fulfilled and future plans developed.

In order to study the situation a questionnaire was issued to 152 secondary schools of the district. Questions were on the various aspects of the Science Club, viz., objectives, activities done and activities planned, budgetary provision, membership, selection of members, sponsors' qualification and experience, etc.

Only 115 replies were received representing a percentage of 76. Out of 115 replies, 47 questionnaires were duly filled in, 27 had not started Science Clubs as yet, but they wish to start these in their schools in due course; 38 schools did not mention anything in their letters except that there is no science club in their schools, 3 schools had established and do not want to start any, 37 schools did not respond at all.

Thus about 31 per cent of the schools in the district have already started science clubs in their schools while about 17 per cent desire to establish the same. This shows that the schools of the district are conscious of this activity and there are future prospects, if proper guidance is given to them.

TABLE I—MEMBERSHIP

Standards	VIII	IX	X	XI	TOTAL
Boys	346	460	576	369	1751
Girls	91	109	129	49	378
Total . ..	437	569	705	418	2129

It can be seen that more boys are members of the science clubs as compared with girls. The highest number of pupils are members in standard X. The

number is increasing from standard VIII to X, and in XI, the membership declines.

Number of Members

Following is the distribution of scores covered by each school.

We can say from Table III that most of the members continue their membership throughout schooling.

Finance

The next query was regarding the aid

TABLE II—STRENGTH OF MEMBERSHIP

Membership strength	191-200	131-140	101-110	71-80	61-70	51-60	41-50	31-40	21-30	11-20	1-10
Number of schools	1	2	1	2	2	4	7	4	8	5	3

Some schools do maintain a large membership but the general tendency is not to exceed 50 which seems to be a manageable group.

Continuity of Members

Regarding the continuation of the members of the science club throughout their schooling, 30 schools responded favourably, 8 in the negative, while the rest 9, either did not respond or responded vaguely. This shows that in majority of the schools pupils continue their membership throughout their schooling. This is a good sign, as the pupils' continued interest is likely to make for good progress in the clubs. It may be also due to the fact that these members need some extra activities to supplement the syllabus in general science which now does not satisfy their needs.

Table III will show the number of pupils in percentages who continue their membership throughout their schooling. This data represents the position in 24 schools, the rest have not given their answers to this question.

from the Central Government. Surprisingly everybody responded to this query in the negative. It is rather difficult to say whether the schools are in the know of this kind of help. About 22 schools say that the budgetary provision has been made by the school itself. The expenses vary from Rs. 25 to Rs. 300.

Selection of Members

The criteria of selection of members given by the schools are as under:

TABLE IV—CRITERIA OF SELECTION USED BY DIFFERENT SCHOOLS

Criteria	*No. of schools*
Those having interest in science or having scientific aptitude or ability.	23
All who wish to join ..	8
50% or more marks in science ..	4
Spirit of extra work	3
Pupils from standard IX & X ..	2
General knowledge in science ..	2
On the basis of test results	2
Fond of reading books	1
Those who know drawing	1
Science teacher's opinion	1

TABLE III—PERCENTAGE OF MEMBERS WHO CONTINUE AS MEMBERS

Percentage of members who continue	100	90	80	70	60	50	40	30	20	10
Number of schools	10	—	3	3	—	3	2	2	—	1

Most of the schools select their members on the basis of interest or aptitude or abilities in science. It is not known how they measure these mental abilities. The second criterion is based on the examination marks in science.

Qualifications and Experience of Sponsors

As regards qualifications and experiences of the sponsors of Science Club the position is as under

TABLE V—QUALIFICATIONS OF SPONSORS

Qualifications	*No. of sponsors*
B Sc., B.Ed	33
B Sc , S.T.C . . .	4
B.Sc. .. .	3
B.Sc failed . ..	1
Undergraduates .. .	3
L. PH. M.A. Ed.B, (Glasgow) .	1
B.A., S.T.C.	2

TABLE VI—TEACHING EXPERIENCE OF SPONSORS

Experience in years	*No. of teachers*
32—33 . . .	1
30—31 .. .	1
28—29 .	1
24—25	1
20—21	1
14—15	1
12—13	2
10—11 . ..	2
8—9	6
6—7	9
4—5	7
2—3	3
0—1	4

Experience of 8 sponsors have not been given by the schools. Most of the sponsors are trained science graduate[s]. Only 6 are either trained arts graduate[s] or undergraduates. In a majority [of] cases their experiences cover the scor[e] from 4 to 9 years which is quite good.

Qualifications and Experience of Helpers

Similarly the qualifications and th[e] experiences of those teachers who hav[e] been associated with this activity are give[n] below :

TABLE VII—QUALIFICATIONS OF HELPERS

Qualifications	*No. of teachers*
B.Sc., B.Ed.	31
B.Sc., S.T.C	4
B.Sc. (Agri.) Untrained Science graduates	2
B.Sc.	[illegible]
M.Sc	1
Trained arts graduates .	[illegible]
B.Com., S.T.C. .	1
Trained or untrained under graduates or matriculates	[illegible]

TABLE VIII—EXPERIENCE OF HELPERS

Experience in years	*No. of teachers*
24—25 . .	1
20—21 .	2
14—15 .	1
12—13 .	1
10—11	1
8—9	1
6—7	[illegible]
4—5 .	[illegible]
2—3	[illegible]
0—1 . ..	12

Most of the associated teachers are trained science graduates. Out of the rest 28 are untrained science graduates. This is also a fairly good picture. But, when we turn to experiences of these teachers, majority score between nil to 3 years only. It seems from the above Tables that there may be a move to associate a fresh teacher as a helper to the experienced sponsors and give them enough experience and training in the conduct of science club

Activities of the Club

The activities which the clubs carried out during the year 1961-62 and the activities that have been planned for the year 1962-63 are shown as under:

TABLE IX—ACTIVITIES OF THE CLUB DURING 1961-62 AND 1962-63

Activities	*No. of schools*	
	1961-62	*1962-63*
Charts and instrument making	20	24
Tours and excursions	10	17
Magazines	8	5
Exhibition	7	14
Library reading	6	8
Recording	6	4
Lectures from experts	5	11
Question box	5	7
Collection	5	8
Paper cutting	3	4
Preparation of tooth powder etc.	3	3
Debating	3	2
Project	3	9
Discussion on topics	2	1
Gardening	2	2
Museum	2	2
First aid	2	2
Experiments	2	—
Films	2	—
Health, hygiene	1	1
Biographies or handbook of life histories	1	5
Science news	1	—

The activities carried out in the year 1961-62 and planned for the year 1962-63 do not differ much and the tendency is the increase in the number of schools for the same activities. There is nothing new in the activities planned for the next year.

Time Devoted to Science Club

Generally the members of the club meet for one hour in a week. The study showed that the members meet mostly after school hours.

Objectives of the Science Club

The head of the schools were asked to give their opinion on the main objectives of the club.

TABLE X THE FREQUENCY OF OBJECTIVES

Description of the objectives	*No. of schools*
To develop creative ability of pupils	26
To make pupils science-minded	20
To develop in pupils the scientific approach towards things and happenings	24
To prepare for an exhibition	8
To develop in pupils keen eye for observation	16
To equip the science laboratory	3
To develop in pupils interest for reading, etc.	6
To develop an ability for research ..	8
To raise the standard of teaching general science	5
To enable the pupils to understand and appreciate the work of science ..	7
To acquaint the pupils with the recent progress of science	12
To enable the pupils to apply their knowledge of science in certain life-situations	18

They had to encircle their objectives they thought were the most important. In all 12 objectives were given to them. Space was also provided for any other objectives to be added if any one wanted to. Table X shows the number of schools against the objectives which they have encircled.

The first three objectives and the last one are selected by majority of the schools. But more or less all the objectives have been considered to be important by some schools.

Two schools have added two more objectives:

1. To enable the students to think more and observe deeply and thus to widen their knowledge of general science.
2. To give ample scope for handling the apparatus and thus improving practical skill.

Mere Activities for the Science Club

Seventeen activities which they can take up for their science club were given to them. They had to tick off only those which they can take up. The following Table represents the number of the activity and in the other row the number of schools who have opined to take up:

TABLE XI—FREQUENCY OF THE NEW OBJECTIVES TO BE TAKEN UP

Activities	*Schools*
First aid	35
Fire fighting	8
Improve and maintain electric lines	8
Give instruction to the public about black out	9
Air raid precautions . ..	9
Hygiene of the village or pond .	29
Food preservation .. .	19
Kitchen gardening .	11
Poultry farming .. .	6
Health, hygiene , ..	26
Nursing	5
Plumbing	0
Radio repairing . .	3
Cycle repairing . ..	14
Wood working	7
Lathe working	0
Assembly of different parts of an equipment	5

It is just possible that these activities require certain tools and the schools may not be in a position to supply them. Also these activities require a trained personnel specialized in these particular branches. This may not be possible for the schools to offer.

The list of activities suggested is by no means comprehensive and a study of the activities that the clubs can take up with or without special aid, requires to be studied.

Central Electrochemical Research Institute

THE Central Electrochemical Research Institute, one of the National Laboratories, was established in Karaikudi in 1953 due to the pioneering efforts of the late Dr. J.C. Ghosh, the late Dr. S.S. Bhatnagar, and by the generous donation of land and money by the late Dr. Rm. Alagappa Chettiar, a noted business magnate and philanthropist of South India. The foundation stone of the Institute was laid in July 1948 by our late beloved Prime Minister Shri Jawaharlal Nehru, whose enthusiasm and inspiring guidance have played no small part in the establishment of this Institute. The Institute was formally declared open by the then Vice-President of India Dr. S. Radhakrishnan in January 1953. It started active research soon after its opening when Dr. B.B. Dey joined as its first Director. After the retirement of Dr. Dey, Prof. K.S.G. Doss took charge of the Institute in February 1957.

Electrochemical research is alive with great potentialities which may unfold novel techniques, improved methods and new materials and thus serve the cause of industry in the country to a great extent. This is especially true in the present context of national planning when more and more thermo- and hydro-electric projects are being established on a country-wide basis. The Institute since its inception has been contributing its mite to the industrial advancement of the nation by conducting research in the fast expanding field of electrochemical science and technology. One of the main objectives of the Institute is the evolution of processes and conditions for the effective utilization of indigenous raw materials. The decennary celebrations of the Institute were held recently in January 1964.

A few of the major equipments available in the laboratory are electron microscope, spectrophotometers, X-ray diffraction unit, rectifiers, precision potentiometers, electrochemograph, and universal microscope.

The work in the Institute is organized under the following sections:

1. Electro-inorganic and organic products
2. Electrothermics and fused salt electrolysis
3. Batteries
4. Electrowinning and Electrodeposition
5. Metal finishing
6. Corrosion
7. Chemical physics
8. Fundamental electrochemistry
9. Electrochemical instrumentation
10. Survey and information

Electro-organic and Inorganic Products

In certain cases, electrochemical methods of preparation of substances have

the following advantages over the conventional chemical methods: (i) easy control of operation (ii) lesser number of unit operations (iii) possibility of employing low grade raw materials, (iv) possibility of obtaining product of desired purity and (*v*) lower cost of production. This section has been engaging itself in working out optimum conditions for the electrochemical production of a number of organic and inorganic chemicals having wide industrial applications.

An electrochemical process has been worked out for the continuous production of cuprous oxide which finds use as a toxic ingredient in anti-fouling compositions used in paints for painting ship bottoms and also as a fungicide in agriculture. The process has a patented cell design and employs cast copper anodes. The process has been leased out to two firms in Calcutta, and the firms have gone into operation.

Good quality manganese dioxide is in great demand in industrial heavy duty cells and miniature dry cells for the army. Electro-chemical methods have been attempted here for preparing manganese dioxide both from sulphate and nitrate solutions.

Potassium perchlorate conforming to specifications was prepared in our pilot plant and supplied to Defence.

Methods for the preparation of potassium cryolite suitable for Defence purposes and sodium cryolite for use in aluminium industry have been standardized employing raw materials like potassium and sodium aluminates and byproduct hydrofluosilicic acid from superphosphate industry. The know-how has been handed over to nine parties so far. The Institute has set up a unit with a capacity of 30 kg. per day for the production of synthetic cryolite at the Guindy Industrial Estate, Madras.

Experimental techniques for the preparation of aminophenols (photographic developers), salicylaldehyde (perfume and dye intermediate) and calcium gluconate (pharmaceutical) have been developed, and handed over to industry. A two-stage process for the production of dialdehyde starch from tapioca starch available in large quantities in the country has been worked out. Dialdehyde starch finds use in tanning, paper industries, textile industry as adhesive, and as tobacco binding material. Suitable procedures for the preparation of benzaldehyde, tolualdehydes, and benzidines have been worked out which are ready for commercial exploitation.

Electrothermics and Fused Salt Electrolysis

Laboratory scale trials for the production of calcium carbide using straight unburnt crystalline limestone and carbonaceous materials like Bararee coke and Neyveli lignite have been carried out.

An electrochemical procedure for the preparation of anhydrous magnesium chloride from magnesite and magnesia has been worked out. The know-how for the production of magnesium from magnesite and bitterns is being worked out and production of magnesium metal in a 2500 amp. cell is being attempted The Government of Madras have sponsored a scheme at a cost of Rs. 3.2 lakhs for the pilot plant trials on the production of magnesium from magnesite. A 1000 amp. cell for the production of sodium metal has been fabricated and operated. It may be mentioned that sodium and magnesium have been produced at the

Institute for the first time in India in pound lots using indigenously available components and locally fabricated equipment.

A 500 amp. cell for producing 5 lb. of misch metal in 24 hours has been running successfully, employing mixed rare earth chlorides fused with calcium chloride. This cerium-iron alloy is used for cigar lighters.

Batteries

Sintered plate nickel-cadmium batteries are used wherever dependability, high rate discharges, good performance at low temperature and ruggedness of construction are pre-requisites. The technical know-how for the indigenous fabrication of those cells has been completely worked out in the laboratory and different steps of sintering, impregnation, forming and assembling have been standardized. A project to prepare lead-acid storage batteries which could give a satisfactory performance at sub-zero temperatures ($-15.5-17.7°C$) with the use of addition agents in the paste prepared for negative plates is being actively pursued in the laboratory. Considerable progress has been made on the fabrication of silver oxide-zinc cells, mercuric oxide cells, magnesium batteries and in the preparation of carbon elements for air-depolarized cells.

Electrowinning and Electrodeposition

The know-how for the preparation of electrolytic manganese from low grade ores has been worked out on a laboratory scale and trials have been conducted on a large scale. One of the officers was deputed to a firm to set up a unit for the production of electrolyic manganese from low grade ores. The know-how for the preparation of manganese sulphate from low grade ores has also been worked out and a non-technical note has been prepared.

Chromium plating is extensively used in the protection of metals against corrosion, for decorative purposes and for mitigating wear and erosion. Further, chromium plated surfaces reduce the tendency of adhesion of 'scales' to metallic surfaces. The Institute has standardized the technical know-how for hard-chromium plating of parts used in various industries, as for example, automobile parts, like piston rings, piston rods for shock absorber, etc., and in steam locomotives for injector delivery ram cones, piston valves rings and piston rings. In textile industry, parts such as cotter pins, silver plate, draw frames, etc., have been chrome-plated for increasing their service life. The know-how for hard chromium plating has been worked out in the Institute and handed over to Defence.

Lead and tin habit alloys are well-known for their use as bearing linings as they possess lubrication properties combined with resistance to corrosion. The Institute has worked out the know-how for lead-tin alloy plating on composite bearing linings and the technique has been demonstrated to a firm in Madras.

Metal powders such as iron powder, zinc powder, copper powder, lead powder, etc., find use in organic reduction reactions, in paints, etc. Suitable methods for the deposition of metal powders have been worked out in the laboratory and these processes were demonstrated to interested parties.

High purity tin is needed in many applications such as in the production of

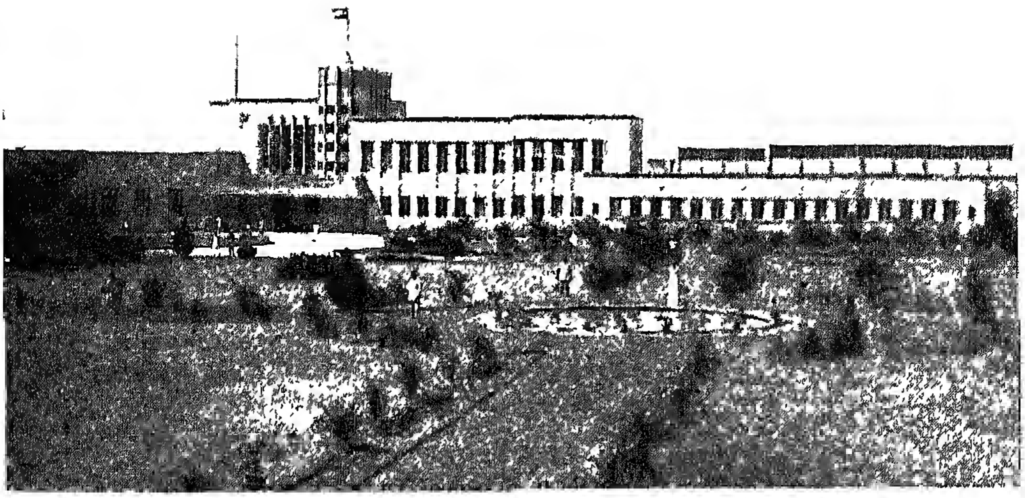


Fig. 1. Central Electrochemical Research Institute, Karaikudi

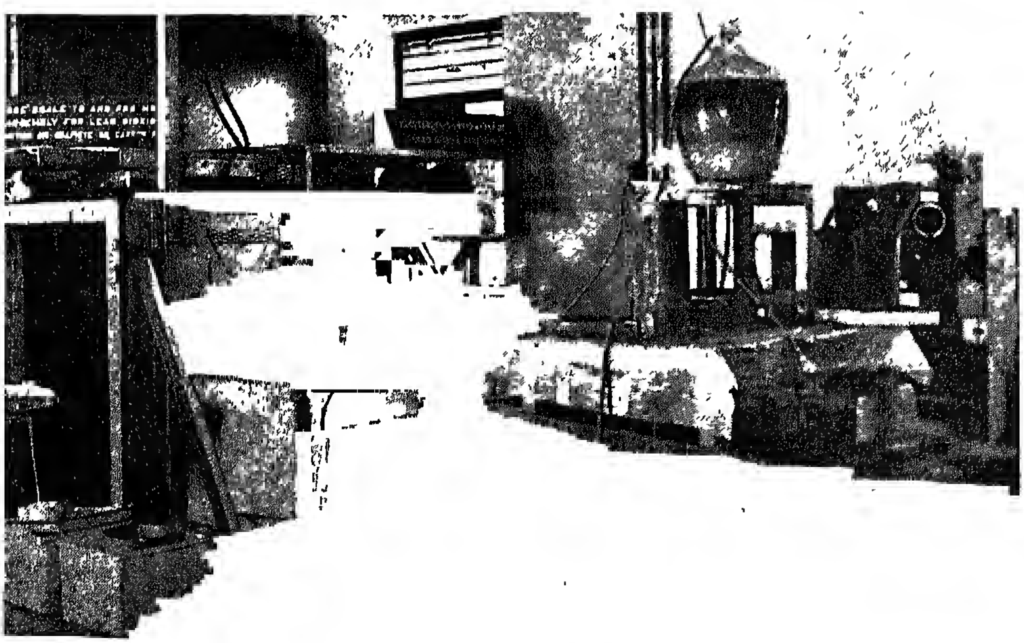


Fig. 2. Set-up for the production of Lead Dioxide Electrodes

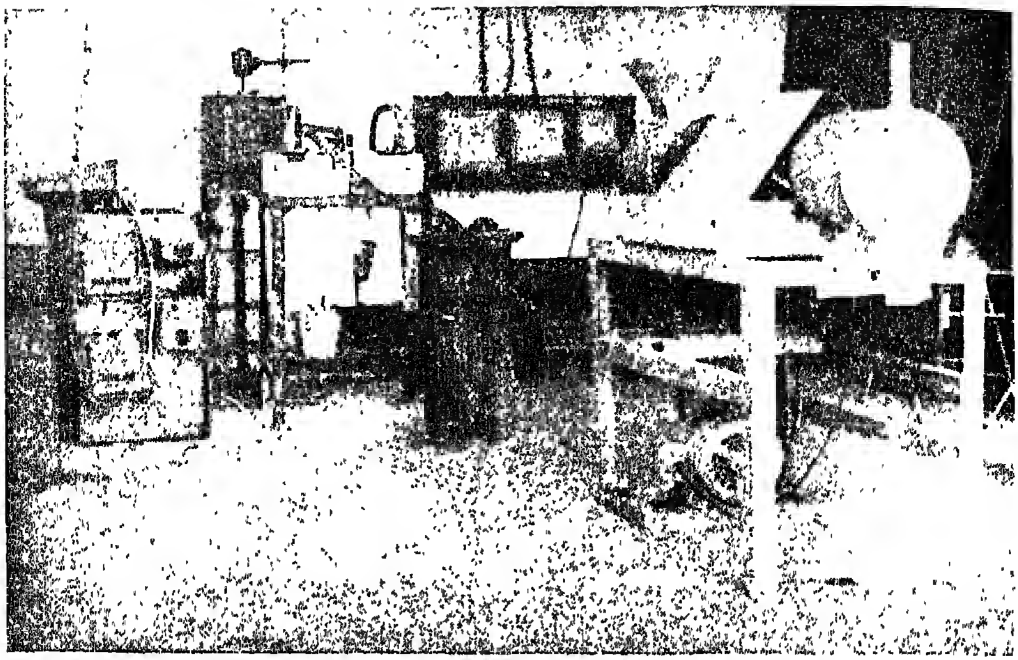


Fig. 3. Set-up for the production of Synthetic Cryolite

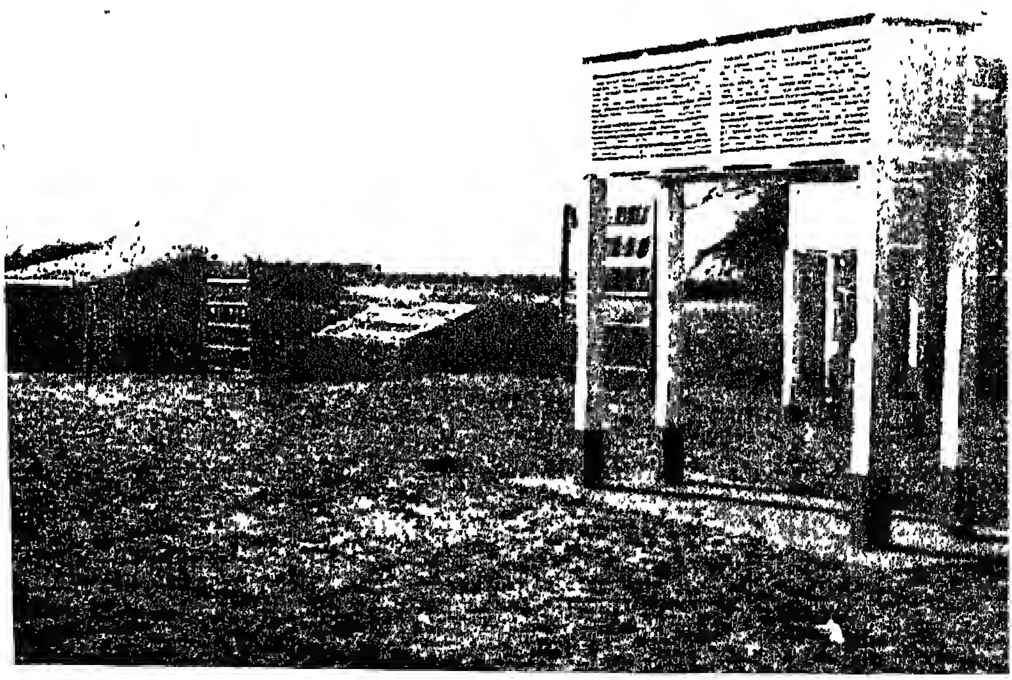


Fig. 4. Corrosion Testing Farm at Mandapam

bell metal and other bronzes The presence of lead impurity in the tin makes it unsuitable in the tinning of food containers and in some bronzes The know-how for the electrolytic refining of scrap-reclaimed tin has been worked out and it has been found possible to obtain tin of 99 9 per cent purity The know-how has been released to a firm in Bombay.

Optimum conditions for the electrolytic refining of fire-refined copper have been established The anode slime was analysed for selenium content which was found to be 2 0 per cent.

The All India Handicrafts Board, New Delhi, have sponsored a scheme for conducting research and experimentation in improved methods of silver plating of copper wire (30 SWG), golden and uni-colouring of imitation jari and gold plating of imitation and real jari at an estimated expenditure of Rs 27,000. Work in this regard is in progress.

Metal Finishing

All the aspects of the know-how in the anodization of aluminium and allied processes such as dyeing, multicolouring, relief design, mottled finish, direct printing and photographic reproduction have been worked out and the same is available for exploitation by industry. The processes have been demonstrated to interested parties

The know-how for the electrochemical etching of commercial aluminium for use in electrolytic capacitors has been worked out. Optimum conditions were established for etching and forming of super-purity aluminium for use as anode in the aluminium electrolytic capacitors This know-how was given to a firm in Madras. Tantalum electrolytic capacitors are noted for their small size and good performance and are in demand in miniaturized electronic devices Investigations on the development of foil type tantalum capacitors are in progress

Corrosion

The method of vapour phase inhibition for preservation of metal stores from corrosion has been studied and cheap dye-stuff intermediates like meta-dinitro-benzene and beta-naphthol have been successfully employed for this purpose

The conditions prevailing inside weaving sheds promote rapid rusting of various parts of the textile machinery and experiments carried out here have shown that cadmium plating of parts like wire-healds, droppers and reeds (which cannot be painted) will obviate the need for frequent replacement.

An outstation has been opened at Mandapam Camp for carrying out field investigations on corrosion under tropical marine conditions. Exposure yards have also been located in the premises of Madras Port Trust to study the protective treatments to be given under industrial marine conditions. One more exposure station has been set up at Madurai

A scheme on the investigation into the corrosion of reinforcement in RCBW and RCCB, sponsored by the National Buildings Organization, New Delhi, has been in progress since October 1, 19[illegible] A comprehensive investigation into the conditions under which reinforcements used in roofing constructions show premature failure, is in progress. Work carried out so far indicates that the cement covers the reinforcement which is protective can cease to be protective if the concentration of their salts increases

Chemical Physics

Lead sulphide photocells are known to be quite rugged and their sensitivity extends into the infra-red region. The know-how for the design and development of lead sulphide cells is being worked out.

The fabrication of Finch type electron diffraction camera undertaken by the Institute has reached the stage of near completion and the camera will be shortly commissioned. Most of the parts excepting diffusion pumps, valves and high tension equipment were fabricated in the Institute. The operating voltage of the unit is 55 KV.

Fundamental Electrochemistry

One of the important results the Institute has recorded is the general formulation for the redoxokinetic effect which has been considered as the most elegant and general one so far given anywhere in the world. Similarly, the slow relaxation effects at charged mercury-water interfaces discovered here not only explain a number of obscure phenomena in fundamental electrochemistry but also appear to be useful in interpreting biophysical phenomena such as muscle and nerve actions, since slow relaxation effects appear to occur at all aqueous charged interfaces.

Electrochemical Instrumentation

In chlor-alkali industry it is often found that the chlorine produced gets mixed up with considerable amounts of hydrogen gas leading to serious explosions. An improvement has been effected in the design of the instrument for monitoring hydrogen content of the chlorine gas by replacing platinum elements with thermaly sensitive semi-conductors (thermistors) having negative temperature co-efficient of the order of 4 per cent. This improvement has several advantages like ease of construction, installation and operation, besides ensuring high precision.

An instrument for checking the polarity of dry storage batteries has been designed and fabricated employing an electrometer circuit with a Philips 4067 tube.

In industrial electroplating it is often necessary to determine the thickness of electroplates for control purposes. A simple, reliable and precise method for this has been developed based on anodic stripping. The solutions suitable for the usual industrial electroplates have been worked out. Another novel technique based on the impedance change of the stripping cell has also been developed for determining the thickness. In this method, a small well-defined area of the electroplate is dissolved out by passing a constant current in the system containing a suitable stripping solution.

An instrument for detection of corrosion of mild steel reinforcements in buildings has been developed using a method based on the wide difference in the magnetic permeability of the iron piece and that of iron oxide embedded within the reinforced concrete.

An electronic null indicator using glass electrodes has been designed which in conjunction with external potentiometer and galvanometer can make precise measurements of pH of solutions.

Future Plan

Some of the important and modern fields in which the Institute proposes to undertake research are (1) fundamental and applied aspects of fuel cells, (2) production and application of metals like aluminium, manganese, titanium, mag-

nesium, thorium and cerium, which are most important from the point of view of India's economy, (3) solar batteries, (4) electrolytic devices, (5) photocells, (6) electroluminescence, (7) ferrites, (8) ozone, (9) Cottrell precipitators and (10) perm-selective membranes.

Refresher Courses

The Institute conducts refresher courses in electroplating, corrosion and its prevention, and storage battery technology every year for the benefit of industrial personnel and persons from government and non-government organizations. The Institute's library has over 15,000 volumes on subjects relating to electrochemistry and allied-branches such as physical chemistry, metallurgy and chemical engineering and over 300 scientific periodicals relating to the above are being received. The Institute is a Patent Inspection Centre from 1957 and the total number of patents available are over 19,000.

Technical Aid to Industry

Technical aid to industry is being given by answering enquiries and sometimes by visiting industry for on-the-spot examination of the problems and giving advice.

Holding seminars in electrochemistry has become an annual feature of the Institute and these seminars are well attended by eminent scientists from universities, industry and other research organisations both from India and abroad. The Institute participates in many of the exhibitions organized in the country.

Classroom experiments

Experiments on Germination

1. Weigh 10 g. of bean seeds and let them soak in water for 24 hours. Observe what happens to the seeds after soaking. Wipe the seed with a dry cloth and weigh again. Do you find any increase or decrease in weight ? Explain the difference in weight.

2. Take a thin-walled bottle and fill it half with pea seeds. Fill up the rest of the space with sand and water. Close the bottle with a cork tightly and tie with a wire. Keep this aside for some time and observe what happens. The glass will break because the seeds swell due to absorption of water (Fig. 1)

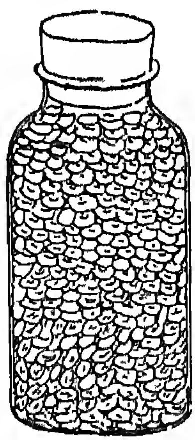


Fig. 1

3. Take two bean seeds and fix them to a cork disc with the help of two needles. One seed should have the scar where the stalk was attached facing downwards and the other seed must have the scar facing upwards. Float the disc in a dish containing a little water. Keep it aside. Observe which seed swells more and reason why. You will find that the seed which has the scar under the surface of water is swollen more, thereby indicating that the seed absorbs water through a tiny hole near the scar (Fig. 2).

4. Place a few swollen bean seeds in each of two flower pots filled with good garden soil. Place one pot in a warm room and another in a cold room. The pot can be kept cold by placing it in the middle of a basin containing freezing mixture (ice plus common

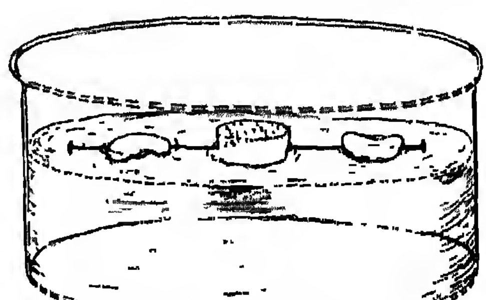


Fig. 2

salt) Observe which seed germinates first. Seeds in the warmer room germinate faster than those in the cold flower pot.

5. Smear molten wax over a few seeds and try to germinate them. Do they germinate ? The seeds will not germinate because they have no means of contact with the external air

6 Take three well grown bean seedlings. In one retain both the seed leaves (cotyledons), in the second remove one seed leaf and in the third remove both the seed leaves. Place them in test tubes containing distilled water as shown in the figure Observe which seedling grows better. You will find that the seedling with both the cotyledons grows for some time, while that with one cotyledon grows for some time only and the third seedling with no cotyledon dies very soon. This shows that the seedling gets food from the cotyledons (Fig. 3).

7. Place a few germinating seeds in the dark and observe. You will find that the seedlings do not turn green. They will be pale yellow.

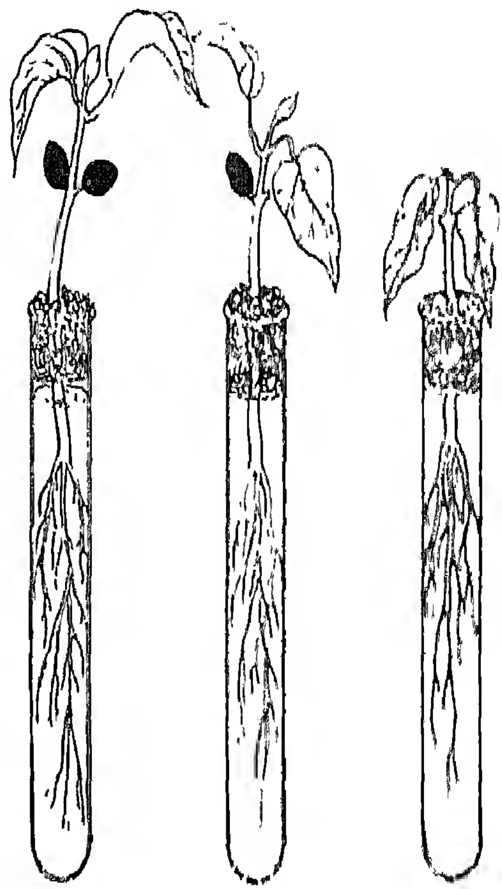


Fig. 3

The above experiments show that for germination of seeds, water, warmth, air and light are necessary.

S. DORAISWAMI

Science abroad

Superconductivity

Arie De Kool

THE Spring of 1962 saw the 50th anniversary of the discovery of one of the strangest physical phenomena, a discovery made in the famous laboratory of Professor Kamerlingh Onnes in Leyden, Holland. The phenomenon was superconductivity, and it is to this day still so strange that no scientist would presume to have completely explained it.

Superconductivity, first discovered by Prof. Kamerlingh Onnes in 1912, means that a material has no electrical resistance whatsoever, and this condition occurs at very low temperatures (those close to the absolute zero, viz. −273° Centigrade or −523° Fahrenheit). Current generated in a ring of superconductive material continues to travel without any loss of force. This situation opens up a field of application for superconductivity in the memory compartments of computers and similar instruments. Such a 'memory' could be built up from superconductive rings; current introduced in one direction would continue to flow without obstruction, and thus data coded by way of this direction could be retained for virtually an unlimited period. The main difficulty, however, lies in the fact that it is not yet possible to economically create and maintain the required low temperature in relatively large spaces. Nevertheless all manufacturers of large electronic calculating and allied machines are extremely interested and have gratefully availed themselves of opportunities to cooperate with the staff of the laboratory where this immense discovery was made.

The Kamerlingh Onnes Laboratory is a veritable Mecca for those interested in experiments at extremely low temperatures. This is no new situation; for fourteen years the laboratory was the only one in the world in which liquid helium could be manufactured; in other words the only one in which conditions could be produced which were necessary for lengthy tests at temperatures at which the movement of molecules and electrons were virtually brought to a standstill. It is not surprising that great scientists such as Madame Curie and Henri Bequerel could, in their day, be seen woking there. They came to see their fellow Nobel Prize winner Kamerlingh

Reprinted from a tape recording of a talk on Radio Netherlands. By Courtesy of the Royal Netherlands Embassy, New Delhi.

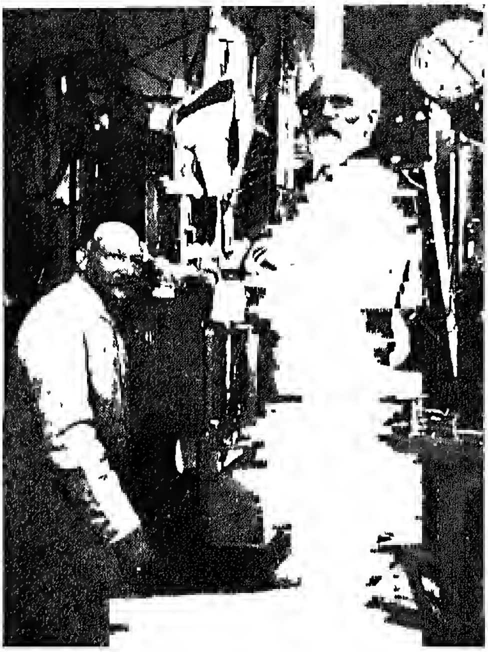


Fig 1 Kamerlingh Onnes (left) with his helium apparatus, 1908.

Onnes, to whom the honour fell in 1913. Of all gases, helium defied attempts to liquify it the longest. All over the world, scientists had reduced all other gases to the liquid state in order to study their properties from a new angle. It was not until July 10, 1908 that Kamerlingh Onnes succeeded in conquering helium. Part of his scientific arsenal was a huge magnet which helped the final experiment forward and downward, hundredths of a degree in temperature at a time. As soon as liquid helium had been produced, Kamerlingh Onnes began to encounter its remarkable properties. He discovered, for example, that if liquid helium were placed in a glass tumbler it crept along the sides and escaped; in other words it 'climbed out of the glass'. Like all other fluids, however, helium possessed the property of remaining at evaporation temperature until evaporation was complete (water boiled in an open vessel will not exceed 100° C.). This meant that liquid helium was a first class source of low temperature and that with it all manner of experiments could be carried out on a wide range of materials at temperatures never achieved. Even at this time a theory existed in regard to the behaviour of electrical conductors at very low temperatures. The propagation of current in conductors results from the fact that the particles surrounding the nuclei of the atoms are relatively 'loose' and thus pass through the material fairly easily. The current encounters a certain resistance along its path, and according to the ruling theories of the day this resistance arose from the difficulty involved in freeing the electrons from their path around the atom nuclei. It was known that heat was involved in the movement of particles in the material, and thus it was to a degree natural to assume that less movement would occur as the temperature of the material fell, in other words that the electrons would adhere more closely to their path. The great physicist Lord Kelvin had prophesied that if the temperature could be brought low enough, the electrons would 'freeze solid' at a given point, at which the conductor would cease to conduct.

Prof. Kamerlingh Onnes had an opportunity to put Kelvin's theory to the test and he grasped it. Together with his assistants Dr. C. Dorsman and Mr (later Professor) G. Holst, he carried out a wide range of electrical tests which showed that with gold and platinum the resistance ceased to vary at temperature of between four and two degrees above

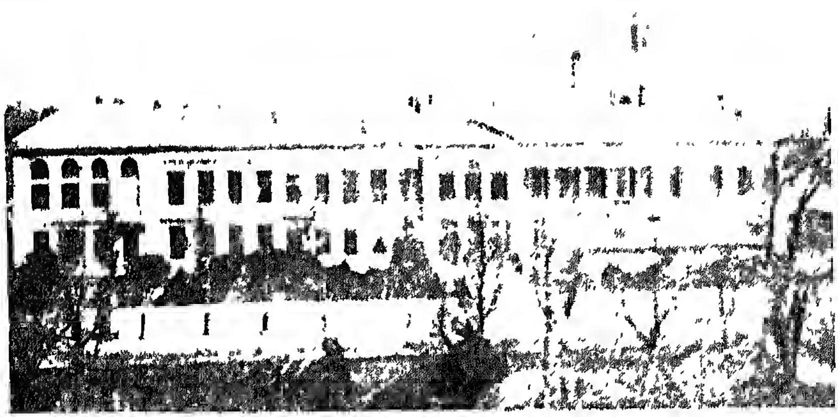


Fig. 2. The Cryogenic Laboratory at Leyden in 1922

Absolute Zero. Somewhat foreign to the theory of Kelvin was that—as was known—the resistance became steadily less as the temperature fell and that Kelvin clearly anticipated a sudden movement from very low to very high resistance. Strange as this was, Kamerlingh Onnes was even more intrigued by the fact that resistance of the materials ceased to diminish at temperatures between 4 and 2 degrees. This he attributed to impurities in the samples and decided to repeat the experiment using as the conductor mercury, which was much easier to obtain in pure form than gold or platinum. The actual test was carried out by Holst and he came to the amazing discovery that when the temperature reached 4.2° above Absolute Zero, the resistance of the mercury suddenly disappeared altogether? Thinking that there must have been an error somewhere, he checked and re-checked his calculations and his instruments, but whatever he did the result was same: at 4.2° Kelvin, the mercury ceased to display any resistance of sufficient size to measure.

On April 28, 1911, Professor Kamerlingh Onnes reported on his findings to a gathering of the Royal Netherlands Academy of Sciences.

Later it was proved that the property of superconductivity was not confined to mercury. It was also found in tin, lead, aluminium, cadmium, titanium and many other primary metals and also in metal alloys. Strangely enough copper, which is regarded as one of the best conductors at normal temperatures, proved not to possess properties of superconductivity.

Kamerlingh Onnes immediately recognised the immense possibilities for his discovery in the field of electrotechnology. He was convinced that the existence of materials with absolutely no electrical resistace would open

up innumerable possibilities. But this conviction was premature. The main problems still to be faced were that the new and wonderful property tended to disappear under the influence of magnetism—which was required in order to achieve the extremely low temperatures involved and that superconductivity disappeared if excessive currents were passed through the material.

It was a long time before superconductivity could be applied in practice. The need on the part of industry engaged in electronics to register and retain data—as for example in the memories of computers—has, however, by now led to a real search for practical applica- of the property.

The Kamerlingh Onnes Laboratory in Leyden is still one of the most important—perhaps even the most important—centre of research in this 'cryogenic' field. The situation may, however, not be to the entire satisfaction of industry because the university of which the laboratory forms a part is interested only in science for its own sake and is not keen on any ties with industry which could exercise a limiting influence on its work!

In discussions on the practical values of pure science the Kamerlingh Onnes work is often quoted as an example of work that appeared senseless to the economist when it was done. For what in the world could be the sense of getting temperatures near to Absolute Zero? And even the striking results of the work did not appear to be any thing but just an interesting fact. Only now, fifty years after its discovery, is this bit of pure science resulting in practical application.

Radioactive Isotopes for Industry

J. L. Putman

United Kingdom Atomic Energy Authority's Research Laboratory, Wantage, Berkshire

RADIOACTIVE isotopes, produced and exploited by Britain's Atomic Energy Authority in conjunction with its nuclear reactors programme, have played a significant part in British industrial development during the last few years, and large quantities have been exported.

Apart from their considerable use in support of Britain's nuclear power programme itself, techniques based on radioisotopes are contributing to the efficient operation of more conventional power generating stations relying on solid fuel or water power. A recent measurement of cooling water flow rates in a power station under construction is one of a series of tests which are likely to become routine for installations of this type. Flow rates in the neighbourhood of 20,000 tons/hour have been measured in underground ducts by the use of an isotope dilution method with an accuracy of about 2 per cent, thus giving important information as to the efficiency of pumps which could not have been obtained by other means. These and other nucleonic techniques for measuring water flow are also applicable to measuring water flow in hydro-electric stations, where accuracy of about 1 per cent is expected, as already achieved in laboratory experiments.

USE IN COAL MINES

In maintaining supplies of coal and oil fuels, isotopes are also playing an important part. The research department of Britain's National Coal Board this year published details of the 'Midget Miner', a new coal-cutting machine to replace manual operation at the coal face. Thanks to a radioisotope gauge in the cutting head, immediate indication is given when the cutter approaches a coal-shale boundary, thus enabling the machine to be guided along a coal seam to cut only good quality coal. Surface trials have already been completed successfully and there is every evidence that a fully-automatic machine can soon be developed, which is likely to make improvements in the efficiency of coal production.

OIL INDUSTRY

In oil refineries, isotope techniques are finding increasing use in plant inspection and the testing of products.

A tube-wall thickness gauge which relies on the scattering of gamma rays has been commercially available for some years and enables the walls of pipes and storage tanks to be inspected for internal corrosion by a simple measurement from the outside, a method which helps to avoid the costly shut-down of plant.

At least one oil company is using a cheap, reliable gauge employing radioactive tritium for the routine monitoring of sulphur impurities in fuel products

By Courtesy of the British Information Services, New Delhi.

The gauge relies on the selective absorption of very low energy X-rays by any sulphur impurities which may be present.

Transport of fuel oils through underground pipelines from the refineries to storage depots, many miles away, is controlled through radioisotope density gauges. The transmission of gamma rays through a pipe containing the fuel is influenced by the fuel density. So a gauge, once calibrated, can not only detect the passage of an interface between two fuels pumped in succession along the pipe, but can also be used to identify the pipe contents by their density

LUBRICATION

Improved lubricating oils have been developed years earlier than they could otherwise have been, because of the faster, more reliable testing methods offered by the use of radioactive tracers. If a radioactive component such as a piston ring is introduced into a car engine, any worn debris is carried in the circulating lubricant, where it can be detected and measured by means of its radioactivity measurement that the effects of an anti-wear additive can be detected in little more than an hour of engine running and can be measured accurately within a few hours—a fraction of the time needed to produce wear measurable with a micrometer or by weighing The method is also more reliable, since dismantling for measurement is unnecessary and engine performance and wear can be reliably compared under a variety of running conditions. Lubricants developed following such tests are claimed to extend the useful life of a car engine

PROCESS CONTROL

Radioactive thickness gauges are increasingly used to measure and control the thickness of sheet materials in production. Most of the paper produced in Britain is now continuously controlled by this means, with great improvements in the uniformity of products and the elimination of most of the wastage of material which used to attend the change of product in a paper mill. In the rolling of sheet metals, a great step towards automation has been achieved by coupling isotope gauges to serve controls which automatically adjust the pressure of the rollers. Resulting products are more uniform and can comply with finer limits of engineering tolerance besides effecting an economy in raw material. Four British firms are now producing a wide range of industrial thickness gauges to satisfy a considerable export trade as well as the home market.

Industries processing bulk materials, such as cement and fertilisers have for some years used radioactive tracer techniques to measure detailed conditions of flow and mixing in the processing plant. Short-lived radioactive materials allow this to be done without permanent contamination of the product, since the radioactivity can be allowed to decay to a negligible level before release to the public. One firm, investigating the efficiency of the mixing of special ingredients into cattle food, was able to show with radioactive tracers that adequate mixing was achieved in half the time actually used in production and achieved great economies in machine time by reducing the mixing period.

STERILISATION

A new feature in the application of radioactivity is the use of radiation from large sources to sterilise pharmaceuticals and surgical appliances. A pilot plant set up by Britain's Atomic Energy Autho-

rity at Wantage, containing 250,000 curies of cobalt 60 produced in British reactors has demonstrated convincingly that many such products can be sterilised more reliably than by orthodox methods, at competitive prices This will be of tremendous importance in the mass production of hypodermic syringes and needles as well as surgical dressings and other appliances.

After two years' successful operation of this plant, known as the Package Irradiation Plant, which is mainly used for the sterilisation of medical equipment, the Atomic Energy Authority has decided that the development of irradiation plants in Britain will best be carried out in collaboration with industry, and has completed manufacturing arrangements with several companies.

These are only a few examples of the many ways in which radioisotopes are being employed to the benefit of British industry Their use is still increasing. In the Thames estuary, near London, the shipping channels are kept open by improved dredging techniques resulting in part from an investigation of silt movement made with radioisotopes some years ago - the first of its kind in the world – and in other fields too, the limits of past research with radioisotopes continue to yield improvements in productivity and the efficient use of manpower and equipment.

The recent legislation governing the use and storage of radioactive materials will stimulate, rather than impede this progress, by increasing public confidence in radioisotopes as the servants of industry.

Efforts to Find a Cause of Cancer

P. Wangham

SCIENTISTS are able to do wonderful things in sending rockets to the moon and bounce television pictures off man-made satellite but cannot stop the mysterious process by which in one human individual a tiny cell divides and starts a cancer.

All living cells have the ability to divide and reproduce themselves when necessary. But for this fact wounds will not heal, children will not grow. But the ability of cells to increase their number is usually controlled. Why do the cells divide and what controls the cell division we do not know. It is also not known why under some circumstances the cells instead of dividing in a regular orderly manner divide in a chaotic and disorderly manner. They continue to grow at the expense of healthy cells and they also migrate to other parts of the body and there start secondary growths.

For such a thing to happen, something must happen to the hereditary material inside a cell—the deoxyribonucleic acid, or DNA. This causes the normal state change to the abnormal state. Once an abnormal cell is formed, it in turn produces other abnormal cells.

Thus the aim of cancer research is to discover this change in the cells' hereditary properties. Only in recent years real progress has been made on this point, the discovery of the structure of the DNA molecule and of the 'code' which determines what kind of hereditary characteristics are to be passed on. This revolutionary discovery brought Nobel Prizes to four scientists. This knowledge can be exploited to obtain an understanding as to why the normal pattern of hereditary information gets upset.

In some types of cancer the disrupting agent is virus. This suspicion started by experiments of cancer in chickens conducted in 1922. More evidence has been gathered recently and now nearly 22 viruses have been discovered which can cause *leukaemia, another type of cancer* in rodents. It has been established from circumstantial evidence that a certain type of cancer common in parts of Africa was of viral origin. This cancer known as lymphoma affects the jaw in young children and it seems to be restricted to certain climatic condition. It is suggested that the responsible organism is a virus carried by a mosquito or some other insects.

The human body always makes some attempt to contain a cancerous growth and only rarely this attempt is successful. Possibly the human body is capable of producing antibodies to a malignant growth. It is a major problem trying to graft skin or organs such as a healthy kidney from someone else on a human being. The 'host' reacts to the foreign cells as invaders. However badly it may need them, they are rejected. The very presence of foreign cells stimulates

Adapted from 'All out effort to find the cause of cancer' in SPECTRUM, p. [illegible], April, [illegible].

the production of antibodies which are antagonistic to the invaders and the host cells refuse to co-exist with them.

Treating cancers by drugs has been disappointing. The sulphonamides and antibiotics act against bacteria but leave living tissues alone. Some drugs which do have some effect and destroy cancer cells have other serious side effects and cause difficulties.

Surgery is the oldest and the simplest method of treatment. If the job is done in time before any secondary growth has begun it can be completely successful. In modern times with the recent advances in surgery and anaesthetics the surgeon can reach parts of the body in which it was impossible to work 20 years ago.

A more powerful tool is the X-rays. The X-rays upset the electrical balance of ions within the cells but the rays are not selective and they have to be aimed at the abnormal cells. They may also not kill all the cancer cells and the surviving ones may continue the cancerous growth.

It is now possible to direct at a tumour an X-ray from an apparatus using several million volts and to aim it with microscopic correctness at a tumour deep in the body tissue, so that radiation does not harm healthy cells. Some of the radioactive substances which have become available as by-products in the nuclear reactors have even a greater potential. It has been shown by research that if cancer cells are given oxygen in excess, the effect of radiation on such cells is greater. Thus patients receive irradiation of their tumours while they are in a highly oxygenated atmosphere. It has been found that if radioactive phosphorus is injected near the tumour the uptake of radioactive material by the tumour is greatest just before cell division. When a specially made Geiger counter indicates greatest activity by the cancer then is the moment to use radiation. A cancer is more vulnerable to X-rays just before it divides.

Diagnosis of cancer is also becoming a more and more skilled affair. Numerous ways have been developed of scanning human organs -- stomach, lungs and so on by means of ingenious optical instruments. Some of these are gastroscope or broncoscope. These are used with miniature television cameras on them so that the doctor can observe more easily any abnormal changes taking place in the human organs.

Diseased areas usually send out different amounts of heat from normal areas and it is possible to produce a 'map' of the body in which surface areas strong in infra-red radiation are clearly picked out. Certain parts which are affected show increase in blood circulation and hence show a rise in temperature.

All these researches are bound to be slow until scientists can give answer to the basic question 'why does a cell undergo malignant change', but the search for the answer is a continuous one and the scientists are trying to piece information to give, and the next piece of information may be a vital one.

Young folks corner

Scientists You Should Know

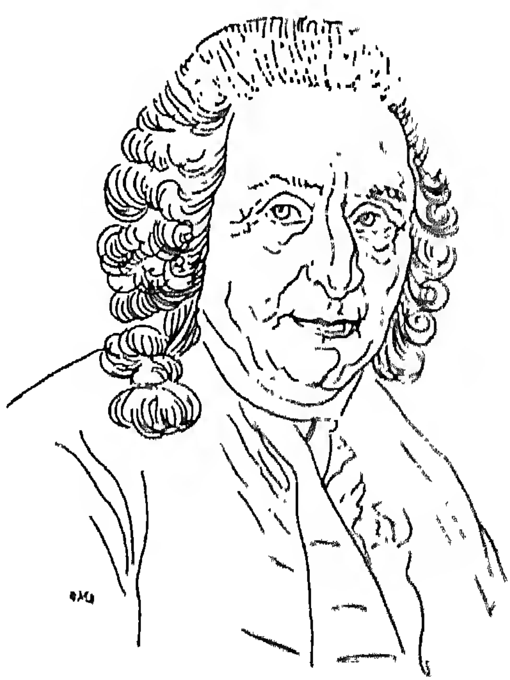
Carolus Linnaeus 1707-1778

EXPLORATIONS by travellers in every part of the globe have resulted in an enormous increase in the knowledge of plants and there were nearly two thousand forms of plants known before the 16th century. Today there are more than 840,000 kinds of animals and over 345,000 kinds of plants known to biologists. The study of plants becomes easy if the plants are arranged and classified properly.

Earlier biologists separated plants into such groups as herbs, shrubs and trees; *and animals into categories like water* animals, land animals and air animals. This lacked precision In the eighteenth century, Carolus Linnaeus transformed this chaos into order and devised a scheme by which plants and animals could be arranged methodically. Linnaeus, was the father of modern systematics, who as a naturalist ranks second only to Charles Darwin.

Linnaeus was born on May 13,1707. His father Nils Linnaeus, a Swedish clergyman had a great affection for plants and was reputed to have an unusual collection of them. This love for plants was transferred to young Carolus, who even as a boy spent many of his leisure hours collecting animals and plants. The father wanted his son to enter the church but young Linnaeus was determined to become a physician and a botanist. The father had to accept this decision and both took a pledge of devotion to science.

At the school he proved a complete failure and the authorities of the school wrote to his father that he would do well to train his son as a



Carolus Linnaeus (1707 [illegible]

cobbler. However, the boy's tutor in physics, Dr. Rothman noticed in him a special aptitude for natural sciences and persuaded his father to let the boy continue his studies. He also supplied Carolus with Pliny's *Natural History* and the works of Joseph de Tournefort and Herman Boerhaave. This was the turning point in young Linnaeus's career. It soon became apparent that despite his failures in studies, Linnaeus had extraordinary abilities and a great aptitude in certain directions.

When he went to the University of Lund in 1727, and to the University of Uppsala in 1728 Linnaeus hardly had any money. The hope of getting some part-time employment to supplement his income was also slender. He was in such a state that he was forced to mend his shoes himself with birch bark and paper. However, at the University of Lund where Linnaeus took his first lesson in medicine, he impressed his professors greatly by his mastering of methods in rearing medicinal plants. He also drew up a plan for classifying birds by the shape of the beak and claw. It was round about this time that Linnaeus made the greatest contribution of his life, the classification of flowers according to their sex organs.

This, however, was not entirely original with Linnaeus. Vaillant, a French author, had already recognized plants that produce egg-like structures, others which produce pollen or sperm: still others which were hermaphrodite combining both male and female organs. Vaillant died before he could establish a classification based on this scheme. Linnaeus took it up and applied it to the flowers as a whole. Under the title of *Marriage of the Flowers*, he published in the year 1729 at the age of twenty-two a brief academic treatise.

In 1732 the Academy of Sciences at Uppsala sent him to explore the plant life of Lapland. He travelled about 4,600 miles on foot, horse back, and in crude boats. Several times he was so short of food that his strength nearly gave away. For days together he walked through the swamplands where he frequently sank to his knees in the mud. His bed was made up of two layers of moss, one for a mattress and the other for a blanket. Linnaeus had to face a lot of other difficulties too including being shot at by the suspicious people of the Lapland.

It was the first extensive field trip in the history of science. Linnaeus's equipment consisted of a measuring stick, telescope, magnifying glass, knife, fowling piece, paper for drying plants—and above all a mind as open and sparkling as the spring morning.

Six months later a wiry tanned fellow strode into the rooms of Uppsala's Scientific Society. He was able to amass more first hand knowledge of living nature than any scientist before. Meanwhile, his fame spread, and Sweden began to realize that she had a great son in Carolus Linnaeus.

Linnaeus developed a scheme of classification according to which there was a uniform method of naming plants and animals according to their natural relationships. During his life time Linnaeus wrote several books on Natural History, the most important of which was *Systema Naturae*. This included a classification of every animal and plant known at that time. Besides, he established the *Binomial system* which is very simple, and here every plant and animal has two Latin names.

The first is the generic and the second is the specific name. Thus man is *Homo sapiens* and mango is *Mangifera indica.* It was now possible for the biologists to refer specifically to a particular organism. In other words Linnaeus may well be credited with establishing a means of communication in biology. As a result of this, the plants and animals were classified into well marked categories which not only makes their study easier but also indicates the relationships between various kinds of organisms. Perceiving how each living thing was related to the other, he revealed the noble and beautiful order that is Nature. His *Systema Naturae* had only 14 pages to start with and by 1768 when its 12th edition appeared, it had 2,500 pages.

Linnaeus also introduced certainty and precision to the description of plants. Besides he formulated the sexual system of classification, according to which twenty-four 'classes' of flowers were established, each based on the number of stamens (the male reproductive organs of the flowers) and their insertion. Each class was subdivided into a number of 'orders', according to the form of the female organ (pistil) Although this was an artificial system, it had a wide and immediate following due to its simplicity and ease of use. Linnaeus's outstanding ability lay in his peerless capacity for dissecting, diagnosing and describing plants and giving each one of them a specific name.

Soon every serious botanist and a physician needed a copy of the *Genera Plantarum* to guide him from the confusion of the plant forms. He was making an eternal classification and an embodiment of perfect design that covered all living things, animals and rocks, plants and flowers. This kind of immortality was the botanist's reward for his exacting labours. He also became renowned as the author of an all embracing *Systema Naturae* (1935), a manifestation of God's will.

He visited England in 1736 where Professor Dillenius became so absorbed in the Linnaean system that he offered the Swede half his salary if he would remain and teach, but he declined. Later he went to Holland and after several years of stay he returned to settle as a physician in Stockholm where he subsequently married Sara Elizabeth in 1739. During his stay in Holland he published the *Genera Plantarum* (1737), and *Flora Lapponia* (1737).

He was appointed as Professor of Botany and Medicine at the University of Uppsala and rejoiced at being 'freed from the wretched practice in Stockholm'. He was henceforth able to teach, collect, and investigate plants according to his fancy. He was an enthusiastic cultivator and developed the most richly stocked garden of Europe arranged according to his own system. During his professorship he used to conduct many excursions around Uppsala with his students. These were very popular outings often attended by two or three hundred people.

Linnaeus's affection for Sweden was so great that he declined an invitation from King of Spain to settle in that country with a handsome salary and full liberty of conscience. In 1761 he was ennobled and took the name von Linne. At this time he designed his own coat of arms which bore a motto meaning 'to spread fame by deed'.

Linnaeus was an extraordinarily popular teacher and his lectures were attended

by students from all parts of the world with numbered from 500 to 1500. The plants they sent back to their master piled up in the herbarium where Linnaeus probed the secret of flowers that bloomed in far away places.

He lived three score and ten happy years to be laid down at last, with a tolling of bells and blazing of torches, in sombre Uppsala Cathedral.

Linnaeus is popularly known as Linne and even today in botanical classifications and nomenclature we use the suffix Linn., to symbolize the name originally given by Linnaeus. He commanded so much respect that at the time of his death in 1778, his mosaic scheme of creation was accepted everywhere. In his own time, the works of Linnaeus had almost the same authority as Scripture itself. What Linnaeus said was enough to settle all debatable questions in botany and other branches of natural history as well.

After Linnaeus's death in 1778, his collections, library and books were bought by a wealthy young English naturalist who took them to England where they became the cherished possessions of the Linnean Society of London. It has been said of Linnaeus that he found *biology in chaos and left it in cosmos.*

G.S. Paliwal

Test Your Knowledge

What is a Computer ?

An intricate electronic machine which can perform numerical computations millions of times faster than the human brain and hand It has a 'memory' unit in which it stores coded figures and data for use during computation, as well as instructions given it by the operator. Computers can perform acts of choice, carrying on mathematical computations, each step of which is determined by the results of earlier steps. Some computers are used only to do mathematical operations, as in engineering work; some process data and print out results; some can act as though they were machines like airplanes, missiles, etc., subjected to various forces. These work out performance data and indicate best designs. A popular name for any computer is 'mechanical brain'

There are two general computer types : the analogue and the digital.The analogue type employs variable devices such as gears, springs and adjustable electric circuits which can be set in relationships to one another so as to represent the variable elements of a problem. By manipulating the principal, or independent variable, all others are made to follow suit in proper relation, producing a series of instantaneous solutions to the problem. Analogue computers are used to solve operational problems such as directing gunfire, etc. Digital computers simply count, on the principle of adding machines, producing one solution at a time to a specific problem set up beforehand. They are slower than analogue machines, but are preferred for extremely intricate mathematical problems because their results are highly accurate.

Can sound be stored ?

Not as sound. But it can be captured and converted into a photographic image, a magnetic sound track or an irregular channel cut in a plastic surface as in

phonograph records. In each case, to hear the stored sounds it is necessary to convert the 'frozen' waves back into mechanical vibrations, either electrically or by a needle travelling over the sound track and causing a diaphragm to vibrate The methods used today to store sound are so delicately adjusted that even the finest overtones are faithfully captured

What is immunology?

The branch of biochemistry which studies the defence mechanism and seeks new ways to assist it in generating antibodies Its main object is to find serums that will stimulate the blood to make large quantities of antibodies before the invader turns up These serums or vaccines usually consist of bacteria themselves, killed, or weakened, but harmless, but mistaken by the blood system for live and dangerous ones. Bacteria may be grown in animals and the animals' own antibodies used (as in the case of horse serum for typhoid) Occasionally, live bacteria may be used on carefully controlled amounts One division of immunology studies the chemical environment on which bacteria thrive and attempts to devise 'food' for them which will poison them

How does a fluorescent lamp work?

A long glass tube is exhausted of air and then provided with a small amount of mercury There is a small filament at one end, which glows when the lamp is first turned on This glow vapourizes the mercury and fills the tube with mercury vapour The main voltage, impressed between electrodes at the two ends of the tube, energizes this vapour and makes it glow a brilliant violet which includes much ultraviolet light. This latter strikes a coating called a phosphor, consisting of a beryllium salt, covering the inside of the tube, and produces fluorescence a pinkish light that pours out through the glass. The glass does not transmit the ultraviolet light itself.

Charnockites : What are they?

These are a type of granite rocks named after the founder of Calcutta, Job Charnock. It is a granular variety of hypersthene granite which was used for the gravestone of Job Charnock who died in 1693, Charnockites are dark granites used extensively as metal for road making.

Science notes

AMERICAN SCIENTIST UNVEILS GENERATOR OF SUN-LIKE PLASMA

'MAN-MADE pieces of sun' that promise startling advances in fields from metal working to space travel are being generated by one of the most advanced machines of its kind in a Columbia University laboratory.

The new machines create plasma—electrically charged gas—directly in air, free of any enclosing chambers or jackets. Consisting of material in essentially the same form as the sun, the free-burning jets are intensely bright and hot, about 20,000° F. (11,000° C.).

They are believed to be potentially the world's brightest sustained light source. Such free-burning jets produced in the laboratory have attained a brightness three times as great as that of any other steady light source on earth.

Charles Sheer, inventor of free-burning plasma jets demonstrated for dark-goggled newsmen how 'plasma technology is on the threshold of practical application' He defined plasma as an electrically conducting gas, most commonly manifested as a brilliant, intensely hot stream.

He said uses for plasma jets, based on earlier discoveries and operating at 40 per cent efficiency, have already permeated every field of science and technology, including materials fabrication, metalworking, chemical processing, extractive metallurgy, illumination, and aerospace engineering.

Dr. Sheer envisioned a new family of plasma generators, operating at 90 per cent efficiency, that 'could double or triple the payload of plasma-powered space ships voyaging between planets.'

Dr. Sheer forecast a generator in the new family that could light night athletic events or night rescue operations in disaster areas by the 1990's as a kind of miniature sun; a generator that could run a high efficiency torch that would cut and weld at 'phenomenal speed.' He said the new jets would eliminate the ear-shattering jack hammer by silently cutting instead of breaking up concrete.

Dr. Sheer singled out two of his assistants for special tribute. One was Christo Stojanoff, Bulgarian engineer, who escaped to the West over the Berlin Wall a few years ago; the other, Pin-seng Tschang, who was born in Malaya and educated in the United States.

Dr. Sheer demonstrated the jets using an elaborate triple cathode generator, the most advanced research tool in existence for studying free-burning plasma jets.

Three streams of flame, or jets, three-quarter of an inch thick and 18 inches long, spewed forth from an elongated thick needle-shaped tube, suspended from a large generator equipped with metal blocks and swirling tubes and hoses.

The jet temperature was 20,000° F (11,000° C). Dr. Sheer showed how the jets could easily boil tungsten or

slice through concrete—feats far beyond the powers of the hottest combustion torches now in existence.

The jets or streams of flame consist of a highly ionized or electrified gas, such as argon. To generate a plasma jet the gas is forced in its conventional state through porous positive electrodes (anodes) located in the centre of the generator.

At the same time up to 450 amperes of current at 40 to 60 volts flow from three negative electrodes (cathodes) to the anodes in a continuous electric arc discharge. Gas is instantly charged by the arc as it emerges from the anode.

It is the use of a porous anode for introduction of the gas that is the basic idea behind Dr. Sheer's invention of the free-burning jets.

He explained that the intense heat of the gas as a plasma results from the transfer of electrical energy to it, rather than from the chemical reaction of combustion.

'The main objective of research involving this new generator,' Dr. Sheer said, 'is to understand this complex process by which electrical energy is ultimately transferred to the gas. Such knowledge as the studies provide form the basis for the evolution of what may become the new family of plasma generators.'

LENSES OF GAS GUIDE LIGHT BEAMS

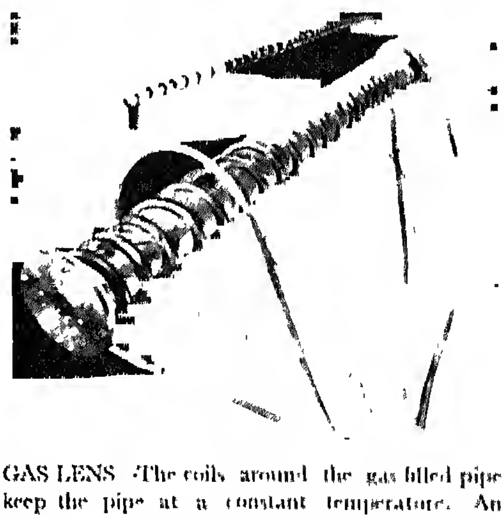
Lenses made of gas, rather than glass, are being tested in the United States to focus and guide light beams around bends and corners in pipes over long distances.

Eventually such light beams can perhaps be used to carry tremendous quantities of information in a revolutionary new communications system, as telephone wires and coaxial cables carry electrical signals which transmit voice or pictures or other information.

Tests show that the gas lenses do not reflect or absorb light nearly as much as conventional optical lenses. The light beams used in the experiments come from a laser, a device that strengthens and purifies light and then emits it in a thin, powerful beam that does not spread out nearly as much over distances as do ordinary light beams.

The tests show that a gas lens or series of lenses can confine a laser beam to a path near the centre of a pipe even if the pipe curves sharply.

In a straight pipe, the lens need not be



GAS LENS: The coils around the gas filled pipe keep the pipe at a constant temperature. An electrical helix heater inside the pipe warms the gas and the resulting convection currents produce an average increase of gas density at the centre of the pipe. The light beam is directed down the axis of the helix where the dense gas refracts it to follow the path of the helix. For demonstration purposes, the helix is shown at the top of this photo instead of inside the pipe. If the helix is bent, the light beam will follow that curve.

powerful because it needs only to compensate for the small natural spreading of the laser beam.

The light beam would normally tend to travel in a straight line even in a curved pipe section, therefore, strong lenses are required to refract the beam according to the pipe's configurations.

In such pipes, the gas lens focuses the beam to keep it from hitting the side of the pipe and, instead, flow in the centre of the pipe.

To accomplish this, the pipe is filled with gas. Because gas becomes increasingly refractive with increased density, the gas inside the pipe is caused to concentrate most heavily in the pipe's centre.

This gaseous region then acts like a prism, deflecting the light beam in the pipe's curvature. The system takes advantage of the well-known scientific phenomenon that light rays curve toward regions which have strong refractive effects or, in scientific language, regions which have a high 'refractive index.' The sharper the curve, the more the light beam must be refracted to keep it from hitting the side of the pipe.

Such pipes could, presumably follow the natural curvature of terrain and could be 'transmission lines' for long distance communications systems.

The gas lenses now being tested are of two different types both designed by Dwight W. Berreman and Andrew R. Hustson, scientists at the Bell Telephone Laboratories in New York.

In one design, a spiralling coil or helix runs through the centre of the gas-filled pipe. The helix is kept a few degrees warmer than the pipe This heats the gas and sets up currents that cause the gas to concentrate in the centre of the pipe, thus increasing the refractive effects in the centre.

The light beam is then aimed through the axis of the helix. Various gases successfully used in the tests include mixtures of air and carbon dioxide, freon and hydrocarbons.

In the second design, two gases of different refractive capacities flow together continuously from opposite directions into a mixing chamber. The gases meet, mix and are drawn out of the chamber.

The light beam passes through the mixing chamber and is focussed in this region. The scientists can focus the light as needed by controlling variations in the refractive index of the transparent gases through thermal expansion, flow and diffusion.

Additional tests are expected to show whether this basically new approach to the guiding of light beams over long distances will lend itself to a commercial long distance communications system.

NEW DEVICE PERMITS SCIENTISTS TO SIMULATE WEIGHTLESSNESS

A machine which permits scientists to simulate weightlessness without leaving the surface of the earth has been developed in the United States.

Known as the 'Zero G Rig,' the device holds a man suspended as if floating in space. He can change his position by propelling himself with airjets on his gloves.

The device is especially useful for simulating a situation in which an astronaut steps outside his spacecraft while in orbit or while travelling to the moon or some other heavenly body. Leaving the spacecraft for short periods may be

necessary for repairing the craft's exterior on lengthy space missions.

In the Zero G Rig, the test subject is strapped into a harness suspended from a crossbar which swings from a boom.

Gimbals and swivels give the test subject complete freedom of movement in any direction, almost as if he were floating in the gravity-free vacuum of space

The device weighs 1.5 tons, but is so delicately balanced that most effects of weightlessness as they occur in space can be accurately simulated

Preparatory to advanced space missions now being planned by the U.S. National Aeronautics and Space Administration (NASA), scientists are duplicating almost every condition an astronaut could conceivably encounter in space.

With the help of a centrifuge and other devices, scientists can check on the effects on men and equipment of several times the forces of gravity experienced normally on earth. In models of spaceships, American scientists are testing the effect of long confinement in cramped quarters under space conditions.

However, a gravitation-free enviroment as exists in space defies precise duplication on earth Brief periods of weightlessness can be produced in airplanes flying in a diving pattern at high speeds, but at best can be maintained only for about one minute.

In such tests at NASA's Marshall Space Flight Centre at Huntsville, Texas, and at the Aerospace Medical Research Laboratory at Wright-Patterson Field, Ohio, technicians performed mechanical repair tasks on an engine inside the cabin of a jet aircraft during brief periods of weightlessness. By repeating the diving maneuver many times, these technicians accumulated weightless time of about an hour.

In the absence of gravity, an astronaut twisting a wrench could turn himself instead of the nut. Striking a conventional hammer could cause the astronaut to be propelled backwards.

American scientists are currently designing special tools for space use, which counteract weightlessness. Some of these tools have been tested in jet flights

The new Zero G Rig is expected to help design and test such tools and techniques by making possible simulated weightlessness for prolonged periods on the surface of the earth.

FLEXIBLE RIBBONS OF LIGHT

Flexible ribbons of electric lighting are now available in the United States by the foot or by the mile (by centimeters or kilometers), as desired, for numerous uses in the home, commerce, architecture and industry.

Known as Panelescent Tape-Lite, these continuous ribbons. .which contain neither light bulbs, tubes, filaments, gases or special fixtures ...can be twisted, coiled, bent or shaped in wrap-around forms even while lit. They operate on ordinary U.S. household current, or from batteries and converters.

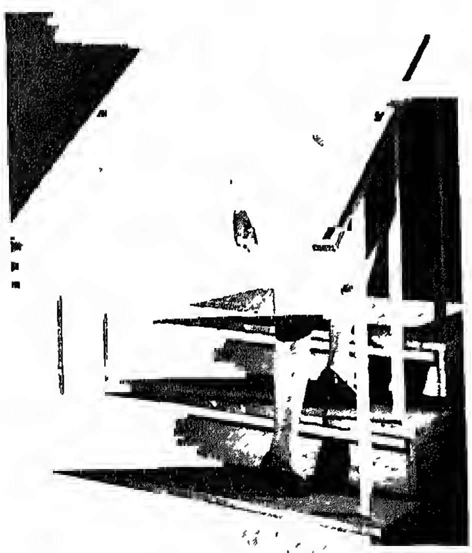
The ribbons are available in four colours blue, green, white and yellow. Other colours and shades can be achieved through plastic overlays. Words and pictures can also be superimposed on the strips with overlays for use in indoor and outdoor advertising, traffic control and for other purposes.

The ribbons are cool to the touch and a 100-foot (30-meter) length of ribbon

requires less electricity than a 100-watt bulb.

Light output is a soft, medium-level illumination, but can be varied slightly with applied voltage.

Possible applications include centre-line strips and pedestrian lanes on streets and highways; 'walls of light' and other decorations in homes; sales displays in stores and offices, interior decorating in



Flexible ribbons of light give these steps and banisters added saftey and a unique decorative touch These strips of light, called Panelescent Tape-Lite, are available in any desired lengths and in a variety of colours.

buildings and furniture design, and for entertainment.

For example, at an ice show at the New York World's Fair, more than 2,000 feet (600 meters) of ribbons were used to create a spectacular 'lights in motion' effect. Stairs, railings and curbs can be marked with the ribbons for night-time safety.

The Tape-Lite ribbons operate on the principle of electroluminescence. Light is obtained by placing phosphor between electrically conductive plates and then applying voltage across the plates. To permit the light to be seen, one of the plates is translucent.

Thus, Tape-Lite ribbons consist of a thin strip of aluminium foil, a layer of phosphorus and a transparent, electricity-conducting coating.

These are sandwiched between protective layers of clear plastic. The entire ribbon is only 1/32 of inch (0.08 centimeter) thick, and is now manufactured in a variety of widths up to 12 inches (30 centimeters). The ribbons are manufactured in standard lengths of 150 feet (45 meters), but can be sealed together by the factory so as to produce any desired lengths. Normal operation requires 120 volts.

Unlike conventional lamps, Tape-Lite ribbons can withstand sudden impact and many other accidental shocks and pressures. In a test, a Tape-Lite ribbon continued to light after being pierced by a bullet.

Though Tape-Lite is usually not subject to abrupt failure as are bulbs, its brightness gradually diminishes with use. It usually operates for 35,000 hours before dimming to half its original brightness, but will continue to give light at gradually diminishing rates for an additional 10,000 hours. If desired it can be dimmed to any point from full brightness to off.

Panelescent Tape-Lite was developed and is manufactured by the Sylvania Electric Products Corporation at Salem, Massachusetts.

From *Science News*, USIS, New Delhi

CATERPILLARS' BRAINS

In an effort to gain better knowledge of the biology of insects and more effective methods of combating insect pests, an Adelaide University professor in South Australia is transplanting caterpillars' brains in a series of microscopic operations.

Professor H.G. Andrewartha, of the university's zoology department, has been conducting his brain transplanting experiments for the past two years. He has succeeded in slowing down or speeding up the life cycle of the common brown grapevine moth.

The life cycle begins with an egg which changes to a caterpillar, then a pupa and then a moth which lays more eggs.

Professor Andrewartha approaches his pin-size task in the manner of a surgeon, by using a needle ground to the shape of a scalpel blade and a pair of watchmaker's forceps. The transplanting is done under a microscope.

Professor Andrewartha said the glands had a similar function to the pituitary gland at the ba e of the brain in humans.

'The pituitary gland is important in controlling the growth and development of a child to maturity' he said.

'In both cases—humans and insects—the control is exerted by the hormones secreted by the glands. With humans we have outsize people and dwarfs because of lack of control of these hormones.

'But with insects their whole life cycle can be interrupted if hormone control of their disapause is altered. The disapause is what makes the insect dormant and a large range of insects become dormant at a certain stage of their life.

'In the life cycle of the brown grapevine moth, we have kept the insect dormant for months until it dies. We have also reversed the process by stopping it becoming dormant.

'More study and understanding of these processes can lead to improved methods of combtaing insect pests as the principles involved are similar.'

Professor Andrewartha said he expected that the experiments would continue for about two more years before they were complete.

NEW TIMBER PROCESS

The Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) has developed a process for protecting timber against decay and attack by borers and termites by saturation with a chemical mixture.

Original research into the protection of timber was carried out as early as 1956 by Mr. N. Tamblyn of the CSIRO Division of Forest Products in Melbourne. By 1960, with further research conducted by Mr. R. Johanson of the same division, a modification of the same process was developed and the mixture was made available in powder form.

The solution is a boro-fluoride chrome arsenic mixture which can be applied either by spraying or dipping. It will dissolve completely even in cold water. It has been found to be so effective that all building timber for Australian Administration contracts in Papua and New Guinea are required to be protective-treated.

The timber is treated when green and then block stacked for several weeks to prevent rapid drying.

By courtesy of the Australian Information Service, New Delhi.

SNAKE VENOM IS NEW HOPE FOR THROMBOSIS PATIENTS

Help for thrombosis sufferers may come from the venom of the pit viper, a highly poisonous Malayan snake. British research workers are now engaged in isolating the substance in the venom which prevents blood clots, and trying to discover the exact way in which it works.

Thrombosis—a major killer—second only to cancer is caused by the formation of a clot in a blood vessel, resulting in obstruction to the flow of blood. A substance that would eliminate the possibility of blood clots would thus be of obvious value in treatment.

The work of isolating the substance is being carried out at the Radcliffe Infirmary in Oxford. Dundee and Liverpool Universities are also engaged in other related biological work.

By courtesy of British Information Service, New Delhi

PROF. P. MAHESHWARI

Prof P. Maheshwari was recently elected a Fellow of the Royal Society, London, a distinction which he richly deserves. He is one of the twelve Indian scientists who have so far been elected as Fellows of the Royal Society. Prof. Maheshwari is a leading botanist in the country and he is well known in international circles for his contributions to the knowledge of plant morphology and embryology. He heads the Department of Botany of the University of Delhi which has now been established as an Advance Centre for Research. Prof. Maheshwari has built up a team of enthusiastic research workers who have also contributed a good deal to our knowledge of plant embryology.

School Science offers its felicitations to Prof. P. Maheshwari for this unique distinction he has achieved We are very happy in the fact that Prof. P. Maheshwari has associated himself with the work of the National Council of Educational Research and Training. He is a member of the Advisory Borad of *School Science* and he is also Chairman of the Biology Textbook Panel. Two sections of the textbook have been published already He has also guided and has taken part in the conferences organized by the Council for framing the science syllabuses of the Regional Colleges of Education.

New trends in science education

Summer Institute Programmes

IN the scheme of reorienting science education, the science teacher occupies a central position. Equipment and textbooks, however good they may be, will not avail much if the teacher does not have adequate mastery over the subject. The teachers at the secondary level are trained science graduates, but they have not had opportunities to keep abreast of modern developments in science. The Summer Institutes are being organised with a view to creating such opportunities by bringing together groups of science teachers in a university or college campus for a period of about five weeks during the summer vacation, and making available to them modern textbooks, improved laboratory techniques and teaching aids, under the supervision of competent directing staff. This will also help to bring the school and university teachers together in a common endeavour to improve the quality and standards of science education.

During the summer of 1963 and 1964 a programme of Summer Institutes was carried out at different centres. The success of these institutes and the reaction of some participants have already been reported in these columns. In June-July 1963, four Summer Institutes were held one each in biology, chemistry, physics and mathematics. Over 150 teachers of secondary schools participated and had the benefit of studying and working the new approaches to science teaching. The materials and the curriculum were those developed in the USA, and each institute also had the benefit of assistance of an American Scientist, who was brought down for this purpose. During June-July 1964 the number of Summer Institutes was increased to 16, four in each of these subjects. At these institutes about 650 teachers from secondary schools, pre-university and intermediate classes and from teacher training colleges had training in laboratory work and used text and other materials prepared in USA. Thirty-two science consultants from USA assisted the academic staff of the 16 institutes in the conduct of the training programmes.

Encouraged by the results achieved, it is proposed to hold during the summer of 1965, 49 Summer Institutes, as detailed below:

SUMMER INSTITUTES IN 1965

Zones	Biology	Chemistry	Physics	Mathematics	Total
Northern	2	[illegible]	2	4	11
Western	2	[illegible]	[illegible]	4	15
Southern	2	3	4	4	12
Eastern	1	[illegible]	[illegible]	[illegible]	11
Total	[illegible]	13	13	16	49

As in the previous years these institutes are being organized by the National Council of Educational Research and Training, the University Grants Commission and the United States Agency for International Development. At an average enrolment of 45 participants at each institute, it is expected that about 2205 teachers will benefit from the experience.

TEACHING MATERIALS AND AIDS

Physics

As in the previous years these institutes will use the new materials developed in USA in the recent past The Physics Institutes will be using the materials produced by the Physical Science Study Committee (PSSC) consisting of four closely inter-connected parts: Part I is the general introduction of time, space and matter. Part II deals with optics and waves where both the particle theory and wave theory are introduced to explain various phenomena. Part III is on mechanics. There is a chapter on heat, molecular motion and the conservation of energy. There is no mention of the specific heat of gases and calorimetry, expansion co-efficients and such topics. Part IV is on electricity and atomic structure, quantum mechanics and relativity theory. Here the student reads about Maxwell, Bohr and Planck. Thus the student is led to see that physics is an integrated subject of study, whose frontiers are changing constantly. The units used are in the M.K S. system instead of the usual C.G.S. system.

The textbook, laboratory guide and the teachers' resource book have been reprinted by the NCERT at low cost and these materials will be used by the participants.

Biology

The Biological Sciences Curriculum Study (BSCS) in the USA prepared new materials presenting an unified, up-to-date treatment of biology for secondary schools. Three versions of high school Biology Textbooks and Laboratory Guides are available – the green version, the yellow version and the blue version. The green version lays emphasis on ecology and evolution; the interaction of populations, communities and the world biome. The yellow version lays emphasis on the cellular approach to plants, animals and micro organisms. The blue version lays stress on the molecular and cellular levels.

The Institutes will be using the yellow version material. NCERT is reprinting the yellow version textbook, the laboratory guide, the teachers' manual for the textbook and the teachers' manual for the laboratory guide. Copies will be ready by the time the institutes begin their work.

Chemistry

In Chemistry, the materials prepared by Chemical Education Material (CHEM) Study Group are being used. Here, chemistry is presented as an experimental science. Unifying principles are developed with the laboratory work providing the base for this development. To see these principles grow out of observations made in the laboratory give the students an exciting picture of how all scientific advances begin. Thus the habit of questioning and of seeking understanding rather than being satisfied with blind acceptance of dogmatic assertions will be cultivated in the students. Also, such an approach liberates the students from the drudgery of endless memorization of

innumerable chemical facts. These materials consisting of a textbook, a laboratory manual and a teachers' guide have also been reprinted by the NCERT.

Mathematics

In Mathematics, texts and commentaries prepared by School Mathematics Study Group (SMSG) will be made use of. These deal with the nature of mathematics, probability and statistics, vector, algebra, linear spaces, matrices, theory of numbers, etc. In each case the subject matter impinges upon the material of the secondary level. The major emphasis is placed on developing real understanding of the foundations of and the logical relationships within mathematics. The main purpose of problems is to test whether the student has sufficient grasp of basic concepts and relations to be able to work out his own solutions and applications. Thus new dimensions have been added and the older concepts have been reorganised and extended in the light of the modern view that the major emphasis on mathematics is concerned with abstract patterns of thought.

The books prepared by the SMSG will also be reprinted by the NCERT, but copies of these reprints will not be available by the time the institutes start this year. However, all the institutes will be using the Indian reprints in the next year.

An Orientation Seminar for the Directors of the Summer Institutes was held for five days commencing from January 30, 1965. Eight American scientists were invited to Delhi to participate in this seminar and conduct the group meetings. They explained the materials to the participants and discussed with them detail of the institutes to be held. Those invited were:

DR. GEORGE W. BURNS	Prof. and Chairman of the Deptt of Botany and Bacteriology, Ohio Wesleyan University Ohio, USA
DR. PAUL R. O'CONNAR	Professor of Chemistry Deptt. of Chemistry University of Minnesota Minneapolis, USA
DR. HOWARD F. FEHR	Professor of Mathematics Education Teachers College Columbia University New York.
DR. ARNOLD B. GROBMAN	Director BSCS Programme University of Colorado Boulder, Colorado.
DR PHILIP S. JASTRAM	Professor of Physics Ohio State University Columbus, Ohio, USA
DR. WILLIAM E. MORRELL	Programme Director Summer Institutes Division National Science Foundation Washington, D.C. USA

Dr. Alfred Romer	Professor of Physics Princeton University Princeton New Jersey.
Dr. D Ransom Whitney	Prof. of Mathematics and Director of Computer Laboratory Ohio State University Columbus, Ohio

SUMMER INSTITUTES TO BE HELD DURING 1965

Subject/Region	*Place*	*Name of the Director*
BIOLOGY		
Northern	AGRA	Prof. P. SINGH Head of the Deptt. of Zoology St. Johns' College, Agra.
	DELHI	Prof. B.R. SESHACHAR Head of the Deptt. of Zoology, Delhi University, Delhi.
Western	INDORE	Prof. K.S. KULSHRESHTHA Head of the Deptt. of Zoology Holkar Science College, Indore.
	JODHPUR	Prof. U.N. CHATTERJEE Head of the Deptt. of Botany Jodhpur University, Jodhpur.
Southern	CALICUT	Prof. A.P. MATHEW Head of the Deptt. of Zoology Mar Ivanious College, Trivandrum.
	MADURAI	Prof. S. KRISHNASWAMY Head of the Deptt. of Zoology Madras University Extension Centre, Ma
Eastern	RANCHI	Prof. K.C. BOSE Head of the Deptt. of Zoology Ranchi University, Ranchi.
CHEMISTRY		
Northern	ALLAHABAD	Prof. SATYA PRAKASH Head of the Deptt. of Chemistry Allahabad University, Allahabad.
	CHANDIGARH	Prof. R.C. PAUL Head of the Deptt. of Chemistry Punjab University, Chandigarh
	LUCKNOW	Prof. L.N. SRIVASTAVA Deptt. of Chemistry Lucknow University, Lucknow.

	VALLABH-VIDYANAGAR	PROF. R.D. PATEL Head of the Deptt. of Chemistry S.V. Vidyapeeth, Vallabhvidyanagar.
Western	JAIPUR	Dr. R.C. MEHROTRA Prof. and Head of the Deptt. of Chemistry, Rajasthan University, Jaipur.
	UJJAIN	Prof. W.V. BHAGAWAT Head of the Deptt. of Chemistry Vikram University, Ujjain.
	NAGPUR	Dr. G. BHAGWANT Reader in Chemistry University Post-graduate Teaching Department, Nagpur University, Nagpur.
Southern	ANNAMALAINAGAR	Prof. V. BALIAH Head of the Deptt. of Chemistry Annamalai University, Annamalainagar
	BANGALORE	Prof. M. SHADAKASHARASWAMY Principal Central College, Bangalore
	HYDERABAD	Prof. V.G. UPADHAYA Reader in the Deptt. of Chemistry University College of Science, Hyderabad
Eastern	BHUBANESWAR	Prof. A.N. BOSE Chemistry Deptt. Regional College of Education Bhubaneswar.
	BURDWAN	Prof. S.K. SIDDHANTA Head of the Deptt. of Chemistry Burdwan University, Burdwan.
	CALCUTTA	Prof. DEBABRATA SEN Deptt. of Chemistry Jadavpur University, Jadavpur, Calcutta.

PHYSICS

Northern	AGRA	Prof. L.P. SHARMA Deptt. of Physics Agra College, Agra.
	CHANDIGARH	Prof. R.M. ANAND Head of the Deptt. of Physics Punjab University, Chandigarh
Western	AHMEDABAD	Shri P.D. PATHAK Reader In-charge of the Deptt. of Physics Gujarat University, Ahmedabad
	SAGAR	Dr. J.D. RANADE Asstt. Prof. in the Deptt. of Physics, Saugar University, Sagar

	AURANGABAD	Prof. V.W. KULKARNI Head of the Deptt. of Physics Milind College of Science, Aurangabad
	AJMER	Prof. D.C. PANDEYA Head of the Deptt. of Physics, Regional College of Education, Ajmer
	UDAIPUR	Shri D.S. KOTHARI Reader in the Deptt. of Physics Udaipur University, Udaipur.
Southern	WALTAIR	Prof. B. RAMACHANDRA RAO Deptt. of Physics Andhra University, Waltair
	TIRUPATI	Dr. S.V. SUBRAHMANYAM Deptt. of Physics Shri Venkateswara University, Tirupati.
	BANGALORE	Prof. SYED ZIAUDDIN Head of the Deptt. of Physics Central College, Bangalore
Eastern	GAUHATI	Shri B.K. BARUA Deptt. of Physics Cotton College, Gauhati.
	PATNA	Prof. B.N. SINGH Head of the Deptt. of Physics Patna University, Patna.
	RAJA-RAMMOHUNPUR	Prof. S.N. SEN Head of the Deptt. of Physics North Bengal University, Raja Rammohunpur.

MATHEMATICS

Northern	ALIGARH	Prof. J A SIDDIQI Head of the Deptt. of Mathematics Aligarh Muslim University, Aligarh.
	ALLAHABAD	Prof R.S. MISHRA Head of the Deptt. of Mathematics Allahabad University, Allahabad.
	KURUKSHETRA	Prof. S.D. CHOPRA Head of the Deptt. of Mathematics Kurukshetra University, Kurukshetra.
	DELHI	Dr. P.D. GUPTA Principal Ramjas College, Delhi.
Western	BARODA	Prof. U N. SINGH Head of the Deptt. of Mathematics M S. University of Baroda, Baroda.

	JABALPUR	Prof. T. PATI Head of the Deptt. of Post-Graduate Studies and Research in Mathematics Jabalpur University, Jabalpur.
	JODHPUR	Shri K.N. MEHRA Acting Head of the Deptt. of Mathematics Jodhpur University, Jodhpur.
	NAGPUR	Dr. B.S. FADNIS Reader in the Post-Graduate Deptt. of Mathematics Nagpur University, Nagpur.
Southern	WALTAIR	Prof. S. MEENAKSHISUNDARAM Head of the Deptt. of Mathematics Andhra University, Waltair.
	DHARWAR	Shri G.S. BENNUR Principal University College of Education, Dharwar.
		Prof. PATTED Professor of Mathematics University College of Education, Dharwar.
	ERNAKULAM	Prof. P. HARIHARAN Head of the Deptt. of Mathematics Kerala University, Trivandrum.
	MADURAI	Prof. M. VENKATARAMAN Head of the Deptt. of Mathematics Madras University Extension Centre, Madurai.
Eastern	RANCHI	Prof. K.M. SAXENA Head of the Deptt. of Mathematics Ranchi University, Ranchi
	GAUHATI	Prof. V.D. THAWANI Head of the Deptt. of Mathematics Gauhati University, Gauhati.
	BURDWAN	Prof. N.L. GHOSH Head of the Deptt. of Mathematics Burdwan University, Burdwan.
	CUTTACK	Prof. R. MOHANTY Head of the Deptt. of Mathematics Ravenshaw College, Cuttack.

Summer Institutes : Inaugural Address

V.V. Narlikar

Chairman, Rajasthan Public Service Commission, Jaipur

I THANK the organizers of the two Summer Institutes, for the honour that they have done me, by inviting me to deliver the inaugural address on this occasion Conscious of the plan and objectives of these Institutes we all realise their importance. A necessary and sufficient condition for their success is the determination of the participants to derive the fullest advantage of the facilities offered under their auspices. Students of mathematics and science know that even good ideas fail to be fruitful for lack of a coordinating theory. Since 'theory' means 'vision' this reminds one of the old saying that where there is no vision the people perish. We have every reason, therefore, to feel grateful to the National Council of Educational Research and Training, the University Grants Commission and the U.S. Agency and experts concerned, but for whose vision, the Institutes would not be coming into existence this summer

We are all conscious of the problems of population explosion in this part of the world. But there is such a thing as ignorance explosion which we cannot ignore If knowledge grows in the arithmetic progression ignorance grows in the geometric progression. This is true for men individually as well as collectively. In the 19th century there were Universalists like Poincare who claimed the whole of mathematics as their province. Some years ago the late von Neumann remarked that he was not sure if any mathematician then living had much of a relationship to more than a quarter of the known mathematics. A similar remark would be true about the limitations of the best theoretical physicists today, although, in the 19th century, Thomson and Tait, popularly known as "T and T'," seemed to be familiar with everything that was known of natural philosophy in their days. Do we not know that, in modern physics, when one unanswered question is satisfied by a new theory or new experimental findings, ten new questions crop up demanding an answer ?

On this background we have to understand the difficulties and handicaps of the average teacher who is confronted, day after day, in his classroom with the task that comprises the four C's. As he has had no opportunities to replenish or refresh his knowledge of the subject he fares more like a stagnant pool than like a running stream of fresh water and is therefore unable to transmit vitality to his pupils. The four C's with which he is concerned are Communication and Control, Concentration and Creation. There is nothing more rewarding and joyful to the teacher than the light of understanding that suddenly floods the face of a pupil. This is the creative activity which he constantly aims at in the classroom.

Inaugural address to the Summer Institutes in Physics and Mathematics Ahmedabad, June 9, 1964.

I will not take your time talking much about Communication and Control. I would, however, take this opportunity to draw your attention to cybernetics, recognised as the creation mainly of the late Norbert Wiener. This is the subject which mathematics and physics teachers can profitably study, at least to understand the problem of putting human beings to human use, in a society that is dominated by machines. Suffice it to say that the teacher in the classroom has to carry on a conversation modifying his words, expressions and strategy by the reactions of his pupils. There is a two-way communication and a control on both the parties. There is no such communication and control when a set address is being read out as I am doing now But this two-way process of communication and control is in evidence when you respond in the morning to the family cat's demand and place a saucerful of milk before it, and the cat protests against it because it is too diluted, and you pacify the cat with some cream, and eventually the cat laps it up thankfully and departs to oblige you with rat-control operations.

In carrying on his conversation with the class the teacher's strategy is to focus the attention of the pupils on some point and make them concentrate on it. There are attractions and distractions, in the class and outside, that obstruct the necessary concentration. The teacher has to be rich in the resources of his head and heart if the concentration is to last till the dawn of creative understanding. On the topics that he has to teach in mathematics or physics he must know much more than what the syllabus implies and he should be aware of a wider field of the subject with its relations to the topics. Felix Klein's lectures on elementary mathematics from an advanced standpoint on the three As (Arithmetic, Algebra and Analysis) and Geometry are well-known. So are the books by Polya, (1) *How to Solve It* and (2) *Mathematics and Plausible Reasoning* and many others written by eminent mathematicians like E.T. Bell, E.C. Titchmarsh, etc. The mathematics teacher has to take to such books as a thirsty man takes to water. If he wants to know what modern mathematics is, there is a neat little article by F. Smithies on the subject, followed by several others in the December 1963 number of the *Mathematical Gazette*. Both the mathematics and physics teachers will find much of interest and profit in every number of the *Scientific American*. *The American Mathematical Monthly* and *Scripta Mathematica* are other journals that have much of interest to our undergraduate teacher. *The Laws of Nature* by R.E. Peierls, *The Evolution of Physics* by A. Einstein and L. Infeld and many other books can be mentioned which give the wider background that our physics teacher needs. I have no doubt that the experts who would be addressing you in the days to come will give you valuable additional information about the literature that must be read.

It is indeed very fortunate that you will have the Summer Institutes for both mathematics and physics working here. Modern mathematics and modern physics, both are heavily indebted to each other. The use of Dirac's δ-function in the quantum theory has led to the mathematical developments of improper functions in the hands of L. Schwarz and others. Non-commutative algebra has led to developments in the quantum theory. Many such examples of mutual indebted-

ness can be given. One is reminded in this connection of the story of the professor of classics at Oxford who was so steeped in his subject that he did his thinking in Greek and Latin. When he was asked what some of his thoughts meant he had to consult a dictionary first. The modern theoretical physicist is in no better position. He is in search of order out of disorder. He starts from axioms or postulates and hypotheses. He thinks in terms of symbols and his results are expressed in symbols. What the results mean he does not know. Heisenberg and Dirac started in this way in their theoretical formulations of the quantum phenomena. Only experimental physicists could tell them if the results implied by discovery of a new order in nature and only pure mathematicians could tell them what mathematical significance their results had Even in pure mathematics a research worker may arrive at a new result the significance of which becomes clear only through the work of other mathematicians.

Distinguishing between pure mathematics and applied mathematics it is sometimes stated that '1+1=2' is a proposition of pure mathematics while 'one apple plus one apple equals two apples' is a proposition of applied mathematics. The proof of the former proposition takes a number of pages of *The Principia Mathematica* and it cannot be understood without acquiring the necessary competence in symbolic logic. As regards the latter proposition nothing like a proof is offered and a rigorous proof would be beyond the intellectual reach of a college freshman. The procedure is something like a recipe for making a pudding. One after another the various instructions are repeated and acted upon in a TV demonstration and, when the pudding is ready, if you still ask for the proof, you are told that the proof of the pudding is in the eating. The body of such demonstrations and verifications which lack rigour (and which are often used in school and college teaching) is contemptuously referred to as 'trivial mathematics'.

The average teacher of mathematics has to ask himself the question whether many of his class demonstrations are not just illustration of 'trivial mathematics'. If he is asked to prove that two right angles are congruent he would either consider it too obvious a proposition to need a proof or he would elaborately provide a demonstration which would be nothing short of cooking the result. Without a knowledge of the elements of the group theory he will not understand a proof like the one given by Felix Klein in his book on Geometry. Standards of rigorous proof have changed. Many of the accepted proofs given by great mathematicians of the 19th century have had to be given up as invalid. The modern mathematics teacher must be well up in rigour as well as vigour. If on one hand he cultivates a direct acquaintance with functions, matrices, groups, rings, topological structures, etc., he must, on the other hand, be familiar with the historical approach to the concept of a function through Fourier's theory of heat conduction and with the historical background of other fundamental concepts. At the same time, the modern physics teacher should know enough about vectors and tensors to understand the broad conclusions of general relativity and enough about matrices and operators to understand what non-compatible obser-

vables are and what the principle of complementarity means. This is essential if young men and women are to be adequately prepared for the intellectual and technological adventures of the space age and nuclear deterrents.

You may have heard of the problem of the three bodies in celestial mechanics. You certainly have heard of the problem of three bodies, that is, of the eternal triangle for you have not read works of fiction and visited the cinema in vain. But have you heard of Kohler's problem of the three stones? Let us consider a stone in India. We call it A. The stone B is in Australia. The stone C is located in the U.S.A The three stones form a system. Is it a purely summative system of three stones? If any one of them is disturbed does anything happen to either of the other two? If nothing happens it is just a summative system. Commonsense says that nothing would happen to the other two and agrees that it is a summative system. Theoretical physics has, however, something different to say.

The principle of the conservation of angular momentum as applied to the earth as a whole, including all of us on the terrestrial surface, makes it quite clear that every time we go for a walk we change the length of the day. $I\omega$ is to be constant and if there is a change in the angular momentum I there has to be a change in the length of the day, viz., $2\pi/\omega$. The displacement of A or B or C means a change in ω. With a change in ω the linear velocity with which each of A,B,C, moves about the axis of rotation changes. This produces change in the relative mass of each. At this stage some one may interrupt me and say that no such effect would arise if one of the three stones is moved without altering the angular momentum I. Well, it is possible that the displacement does not change *the angular momentum. But has not* somebody, of course, a poet said that the stars in their courses would quiver if a finger on the earth is shaken? The theoretical physicist subscribes to this opinion, but, for his own reasons. The inertia of a body depends upon the position and distribution of all the other bodies in the universe If one of the three stones is displaced there would be a change in the inertia of every other body in the universe including the two other stones.

You will see, therefore, that the theoretical physicist is something of a poet and a philosopher and he does not necessarily move, in all that he thinks about, on the familiar plane of commonsense He has to integrate the commonsense which depends on the limited knowledge of here-now-thus phenomena with the knowledge of the long-range phenomena in space and time, subject to the laws of world structure.

According to Newton and Einstein the physical phenomena of the solar system would remain practically unchanged if the rest of the universe were wiped out of existence. But according to one of latest gravitational theories 'the earth would be fried to a crisp' if only half the distant parts of the universe are wiped out I have come to know of this through a private communication from Dr J V Narlikar, Cambridge. This is an illustration of the growing tendency to indentify the cosmical component in the local physical effects At the discussion on elementary particles held under the

auspices of the Royal 'Society, London on Feb. 21 and 22, 1963, V.F. Weisskopf expressed the opinion that 'gravity, electricity and the nuclear world might be ultimately connected by a principle which would link the world of very large dimensions with the structure of elementary particles'. (*Proceedings of the Royal Society* Sec A, Vol. 278, p. 302, 1964)

Like the theoretical physicist the mathematician also has to think on a plane which is often different from the plane of commonsense. Here again we can think of a thought experiment. This will not require as drastic a step as wiping out the whole or half of the whole of the matter outside the solar system. We can imagine a box and an infinite number of small identical tokens differing only in the number mark carried by each. Corresponding to each of the natural numbers 1,2,3,.. ∞ there is a token. At 1 minute to 12, the tokens marked 1 to 10 are put into the box and immediately token No. 1 is taken out. That means only 9 tokens are in the box At ½ of a minute to 12, the tokens marked 11 to 20 are put in but immediately token No. 2 is taken out At 1/3 of a minute to 12, the tokens marked 21 to 30 are put in but token No. 3 is taken out At this stage 27 tokens are in the box. At 1/1000 of a minute to 12, tokens marked 9991 to 10,000 are put in but token No. 1000 is taken out. There will be now 9000 tokens left in the box. The question is, what would happen exactly at 12 ? The mathematician says that the box would be completely empty, no token being left in it. Commonsense says that the tokens are piling up in heaps of 9, 18, 27, 36, .. 90000 and so on and so forth. How can they all disappear ? The mathematician's answer contradicts commonsense. Another way of looking at it brings us to the conclusion that there must be nine times as many in the box as outside. To prove that he is right the mathematician proceeds as follows. Suppose that a token bearing the mark n is left in the box at 12. But this is not possible since the same was taken out when it was $1/n$ of a minute to 12. Now put $n = 1,2,..\infty$ and you will find that no token is left in the box.

The modern teachers of mathematics and physics must be prepared for thought adventures which are likely to be obstructed by what is called commonsense or intuition. He has to cultivate the habit of thinking logically within the framework of his axioms or postulates and hypotheses. He has to be careful that he does not attach new and unwarranted meanings to terms. If he is confronted in his work with xy and yx he should not jump to the conclusion that $xy = yx$. For, who knows? x may mean listening to the inaugural address and y may mean taking the tea. You will agree with me that first listening to the inaugural address and then taking the tea is not the same as first taking the tea and then listening to the inaugural address. Sticking to symbols the mathematician is perfectly noncommitted about them in as much as he does not know what he is talking about nor whether what he says is true. In as much as the physicist resorts to words he must be quite clear what he is talking about and whether what he says is true.

Earlier I have spoken to you of the four Cs of education. The two-way communication and control are necessary to develop the concentration of mind which is indispensable for all creation. The physics teacher has to resort to thought experiments and practicals to fix the attention of his pupil on the subject matter.

Behind every laboratory experiment there is a thought experiment but every thought experiment cannot necessarily be translated into a laboratary experiment. The thought experiment discloses the logic of ideas but limitations of space, time and matter as well as human limitations may make it impossible to translate a thought experiment into a laboratory experiment. Kelvin was able to make important contributions to physics through his thought experiments. In a class demonstration his experiment normally failed because he was no good at practicals. He had to appeal to his audience to forget what he had demonstrated and to remember what results Faraday had obtained in a similar experiment. Kelvin was not much of a success as a teacher. It is the responsibility of the average physics teacher to plan the practicals well so that pupils can perform successfully simple convincing experiments and their imagination is fired by what they see of natural processes and laws. Experimental physics has its victories no less renowned than theoretical physics.

Before I sit down I must tell you of the great transformation that came over Einstein, when he attended the Solway Congress of 1911. He had already made a name by his papers on special relativity, light photons, Brownian motion, etc. He was of the view that the laws of nature must be simple and capable of being expressed by simple mathematical formulae. Whatever work he had already done was free from complicated mathematics. He was, however, impressed by the successful application of higher mathematics to physics in several papers that were read at the Congress. His own work on the theory of gravitation had come to a standstill for want of fruitful mathematical ideas. He became convinced that he could make progress only with the aid of higher mathematics. He was then advised to study Tensor Calculus and Riemannian Geometry. [illegible] aided him, after a few years, [illegible] tensor formulation of his [illegible] tion that is known now as [illegible] relativity. When Einstein [illegible] study of *Tensor Calculus* he was [illegible] thirty-two.

In the world of mathematics and [illegible] things are moving [illegible] one be he a school teacher or a university professor has always [illegible] things to keep abreast of time. You are, indeed, very fortunate in having the resources of the Summer Institute [illegible] open to you. I wish you a [illegible] time, an exciting time [illegible] things and I hope that when [illegible] you will come [illegible] and better [illegible] day tasks of teaching [illegible] are concerned.

News and notes

GENERAL SCIENCE TEXTBOOK PANEL

THE third meeting of the General Science Panel was held at the National Geophysical Research Institute, Hyderabad, from January 28 to 31, 1965.

The materials prepared by the members present in the meeting were read and thoroughly discussed Several modifications were suggested.

The materials prepared by Dr. Kapoor and Dr. Saxena could not be discussed on account of shortage of time. Copies of the materials prepared by Dr. Saxena were given to Dr. Krishan Bahadur, Dr. Venkatsubban and Shri Watts for their opinion. They were requested to send their comments to the Secretary of the Panel at Delhi by February 15 1965. These comments would be discussed with Dr. Saxena when they are received

The Panel met again at Delhi for two days on 1 and 2 March 1965 in the Department of Science Education. The materials not discussed in the Hyderabad meeting were taken up at this meeting Final drafts of materials prepared by other members were considered and the syllabus completed for starting the writing of the textbook. It was decided to hold a writing Workshop at Nainital for two weeks in the month of May, 1965. The chapters written, discussed and completed at Nainital, will be taught at a seminar of secondary school teachers, preferably at Hyderabad in the month of June, 1965 as a try-out. The feed-back in the seminar will help to modify the chapters written by members and taught by them.

BIOLOGY TEXTBOOK PANEL

The second section of the textbook *Biology: A Textbook for Higher Secondary Schools* was published in the last week of January, 1965. This section is titled 'The Diversity of Plant Life'. In its 14 chapters it deals with the structure, economic importance, life history and other features of the different groups of plants. The main theme throughout the book is an evolutionary one. The book has been reviewed elsewhere in this journal.

Section III of the book entitled 'The Diversity of Animal Life' was prepared for the press and is now under print. It consists of 14 chapters and deals with the different classes of vertebrates first and later with the invertebrates. The frog and the human organizms are dealt with in detail but representatives of other groups with common Indian examples are described in the other chapters.

The subsequent sections, viz., IV, V,VI and VII will be printed as one part and this will be sent to the press in a couple of months. By the beginning of the next school year, it is hoped to bring out the entire book in a hard bound form.

SCIENCE TALENT SEARCH SCHEME

The Science Talent Search Examination, 1965 was held on January 3, 1965 at 315 centres distributed all over the country. 6380 candidates took part in

the examination this year as against 6894 in 1964.

Five regional workshops were held at Calcutta, Lucknow, Ahmedabad, Hyderabad and Delhi as part of the follow-up programme for the awardees of Science Talent Search Scheme selected in 1963-64

These workshops were arranged at University centres with a Professor as director and other teachers as resource persons. 210 awardees participated in all these five workshops

Lectures in the five main branches of science, namely physics, chemistry, mathematics, zoology and botany were given by outstanding teachers of the universities and research institutes. This was followed by practicals in science and workshop practice. The awardees were also taken to places of scientific interest. Films on scientific topics obtained from the USIS libraries were screened. Individual and group discussions formed an important part of the lectures during the entire period of the workshop. Certain special lectures by eminent scientists were also arranged.

Attempts were also made to evaluate the outcome of these workshops to enable the Department of Science Education to organise Summer Schools for the talented children to be held in different centres during the summer vacations.

Preliminary arrangements are being made to conduct the first Summer Schools for the awardees of the Science Talent Search Scheme in different zones of India during the summer of 1965.

SCIENCE CLUBS AND SCIENCE FAIRS

During the past year, efforts were made to strengthen the programme of science clubs and science fairs in various ways. A fresh batch of 116 science clubs were started in different schools of the country.

In order to create enthusiasm for Science Club activity, Science Fairs at the levels of district, regional and state were organized. With the help of District Educational Officers about 285 District Level Fairs have already been held till now.

The activity has thus reached most of the schools teaching science. Regional Science Fairs have been organized in about 76 centres, each covering roughly 3 to 4 districts In these fairs, exhibits adjudged good in the district level fairs were exhibited besides a lot of other scientific activity and competitions. As a pilot project, State Level Science Fairs were organized in the States of Mysore and the Punjab. The fair in Punjab at Chandigarh was inaugurated by the Hon. Minister for Education, Shri M.C. Chagla.

It is felt that co-curricular activities in science organized through the science clubs to promote creative work and education in basic skills have been greatly strengthened through the science fairs.

SUPPLEMENTARY READERS

The Department has drawn up a programme of preparation of Supplementary Readers for the school students. A number of titles covering different aspects from various fields of science, including the life and work of eminent Indian scientists, have been taken up. The authors who are writing these Readers are specialists in the fields, they have chosen.

Manuscripts for the following titles have already been recieved and these are being prepared for the press.

i) The Story of Oil.

ii) Rocks Unfold the Past.

iii) The Life and Work of M.N. Saha

iv) Bird Migration.

UNESCO TECHNICAL ASSISTANCE PROGRAMME

Under the UNESCO Technical Assistance Programme, the following experts arrived in January 1965 and will be working with the Department of Science Education.

MR. A.V. BRUONKHANOV—Physics

MR. V.Q. GLOUCHENKOV—Chemistry

Under the same scheme two members of the Department, Shri N.K. Sanyal and Dr. K.N. Saxena have left for U.S.S.R. for a stay of three months. They will study the position of Science Education in that country in their respective fields. Their experience will be very useful when they come back in implementing some programmes of our own Department.

Books
For your science library

Biology: A Textbook for Higher Secondary Schools. Section 2. The Diversity of Plant life. P. MAHESHWARI AND MANOHAR LAL (ed.) National Council of Educational Research and Training, New Delhi, pp. vii+114; Rs 2 75. 1964

THE first section of the book was released in early September. A brief account of this publication along with the background of the textbook programme of the Council was reported in the previous issue of *School Science.* Section I of the book introduced the subject of biology to the students, described the variety of plant and animal life and generally prepared the pupil for a more detailed study in later sections.

Section II of this book, just released, acquaints the readers through its fourteen chapters with the diversity of plant life in more detail. The more familiar plants are taken up first. These are the seed plants (higher plants including angiosperms and gymnosperms), which include trees found in fields and forests and which provide mankind with his three basic necessities—food, shelter and clothing.

The first chapter gives an idea of the general organization of the angiosperm plant. The subsequent chapters give a more detailed information on the form, structure and function of the individual plant organs, such as the root, stem, leaf, flower and seed. The later chapters deal with the lower plant groups, from the virus and bacteria to the pteridophytes. The main theme running through the chapters is the evolutionary process—how plants have gradually evolved from simple to more complex forms The climax of this process is seen in the seed plants The study has been started with the most highly advanced group for the obvious reason that these plant types are readily available, are easy to work with and offer an excellent opportunity to study nature in all her richness of beauty and variety.

The Panel is making efforts to bring out the remaining five sections of the book in quick succession

Investigating with Children: Each vol. 96 pages.

Vol. 1. **Living things,** J.R. WAILES,
Vol. 2. **The Earth,** HUB BELL
Vol. 3 **Atoms and Molecules,** S. TRIEGER
Vol. 4. **Motion,** L. E. DUNN
Vol. 5. **Energy in waves,** L.T. COX
Vol. 6. **Space,** A.L. COSTA.

National Science Teachers Association and National Aeronautics and Space Administration. Teachers Publishing Corporation, Darien, Connecticut. 1964 (India Book House, New Delhi)

THE scientific era in which we live demand that children in the elementary schools have a variety of real science

experiences that lead them to an understanding of the world about them. Through a variety of science experiences, each individual will come to understand and to use scientific processes and skill, as well as to acquire the specific science learnings that will help him intelligently.

It is recognized on all hands that a science teacher of the present day should be alert, up-to-date in his knowledge and be ready to answer all questions that are asked of him by the pupils. Children's questions know no bounds. They are asking questions constantly and these can be answered through numerous activities. Textbook alone is not enough for a teacher to fall back upon. He is to be provided with a guide book and a book of activities. He should also be supplied with background knowledge.

The six handbooks for the teaching of science in the elementary school satisfy to a great extent all the demands cited above. The 'discovery approach' is used throughout. Teachers are provided with questions and suggestions to stimulate further investigation. The subject matter is compact, easy to understand. Each book contains 60-120 scientific demonstrations and activities supported by over 90 illustrations.

Each book covers one area of science and moves from simple concepts to more complex ones and hence the teacher will find the book suitable for all grades.

At the beginning of each chapter are questions that children of different ages might ask. Answers to these are found when children do the activities. The teacher is also supplied with answers to other questions. These will help teachers as they guide the children's learning.

The activities are grouped as *X* for those intended for beginners; *Y* for those require a little more skill, and *Z* for those involving more complex thought pattern. Each chapter concludes with a summary of the main ideas developed in the book. There are also references for further reading.

The books, though intended for American schools will be found useful by teachers here and more so by those who are developing and writing guide books for science teachers in India.

Biology for the Citizen. REID, DOUGLAS. The Modern Living Series, Odhams Press Ltd., Long Acre, London, 1957, pp. 176, 8 s. 6d.

IT is now fairly agreed that every student should have some knowledge of science before he leaves school. In this Age of Science every citizen should be literate in science. And no one will be considered educated unless he knows something about himself and the living things around him. In other words literacy in science should include literacy in biology. There are many outstanding biological problems which have to be dealt with—food supply, population balance, the mentally deficient, diseases, to mention only a few. If we are to survive, these problems must be solved. The biology that is taught in schools should touch aspects of our daily life and behaviour. *Biology for the Citizen* sketches a picture of biology as it affects Man.

The book has ten chapters. The first deals with a short account of the geological history and this is followed by evolution. From the first primitive *Amoeba* feeding, growing and dividing in a primeval pond

we watch the whole parade of life's evolution—the fishes, reptiles, amphibians, birds, animals and plants in all their variety. In the next three chapters, the wonders of the human body, its structure and functions; reproduction, development and heredity are described.

The other subjects of vital interest included are the problem of food supply in relation to population; behaviour patterns in humans, animals and plants, health and disease, moulds, bacteria and viruses.

The outline of biology presented here is in simple language with few technical terms, that every intelligent citizen can easily follow with interest and pleasure.

S. DORAISWAMI

Nobel Prize Winners in Chemistry 1901-1961 EDWARD FARBER, Abelard Schuman Limited, New York. pp. vii+341 $6.50. 1963.

DR. ALFRED NOBEL'S will, to give prizes to outstanding and distinguished scientists, on their achievement in the field of science has been carried out by the Nobel Foundation, since the beginning of the twentieth century

The Nobel Committee of Royal Swedish Academy of Sciences, Stockholm selects the prize winners in the different fields of science and so they did in chemistry. The appreciation and encouragement given to these men who made what their colleagues considered the greatest contribution to the advancement of chemistry, stimulated the progress of science and humanity.

The life and the work of the Nobel Prize winners in chemistry from 1901 to 1961 has been dealt with in this book.

The life sketches will inspire the students and the teachers in scientific discoveries and industrial applications by knowing the origin of interest, consistent efforts, the human factor and the conditions under which these were achieved.

Some of the stories of great events in chemistry, their origin in great personalities and their role in our lives, have also been dealt with in this book Though this book does not give the systematic, complete history of chemistry in the 20th century, it helps to gain knowledge, and inspiration from the previous achievements.

The description of the work given in this book has been taken mostly from the lectures delivered at the time the prizes were awarded. This book will be useful for the students and the teachers to know about the subject as well as the lives of the great chemists of the world.

K.S. BHANDARI

Harper Encyclopaedia of Science. NEWMAN JAMES R. (ed.) Harper and Row, New York. 1963

AN encyclopaedia should cover the scope, depth and details of treatment set by its editors and the contributors, since an encylopaedia almost like an anthology is a work of compromise, selection, preference and taste. *Harper Encyclopaedia* is a compendium of moderate length which covers almost the complete spectrum of science. Good-length and integrated articles on suitably selected topics, with emphasis on explanations rather than on mere cataloguing of facts, differentiate this encyclopaedia from those giving multitudinous dictionary entries.

As a reference work, planned to cover

physical sciences as well as mathematics, logic, the history of philosophy of sciences, and the lives of leading scientists, it is a unique encylopaedia. It can well be said that such a single work was not available earlier.

The addition in a school library of this encyclopaedia available in four volumes, covering 1480 pages with 2,500 illustrations out of which 250 are in colour, should be highly useful for making easy references, both by the teachers and the taught, on scientific topics including the most recent topics.

K.J. KHURANA

Semimicro Chemistry. A High School Laboratory Course. DE BRUYNE K. I., KIRK R.K. and BEERS L.D. HOLT, Rinehart and Winston, Inc., New York, 1962. (India Book House, New Delhi)

THIS practical course in chemistry for the secondary schools of USA employs semimicro apparatus in place of conventional glassware. This is economical both from the point of view of recurring expenditure on chemicals and the reduced cost of the equipment. On the whole the use of semimicro apparatus requires less of bench and cupboard space and is tidier.

The range of the contents cover the higher secondary syllabi of our school adequately and in certain cases even more. Instead of an emphasis on repetitive qualitive analysis and mere preparation and properties of certain gases and compounds, there is gradual development of the study of chemical phenomena starting with laboratory techniques, processes, study of physical phenomena about matter followed by quantitative relationships in chemical changes. Then follows a study of reactions of certain elements and their important compounds and elements of qualitative analysis. The experiments are well-linked with the development of the subject matter in theory.

There are useful experiments on colloids, thermite reaction, chemistry of photography, chemistry of foods, conductivity, fermentation and ionization which normally a secondary student does not perform in the classroom though he may study it in theory. These may easily be incorporated for individual work in our schools. New ideas like simple chromatography are also included which are very useful as introduction to research technique.

Each experiment has an introduction in the form of a preview. The procedure is given in simple language in distinct steps with suitable illustrations wherever necessary. A welcome feature is the number of questions at the end of each experiment which enables the student to assess his experiment and also understand the basic concepts. At the end there is provision for exercise in writing equations.

A list of apparatus and materials needed for this course appears at the end.

The book is organized with 63 experiments generally following the arrangement of topics in *Modern Chemistry* by Dull, Metcalfe and Williams, but it can be used with advantage with any standard chemistry book for the higher secondary stage.

This book will prove useful if it is published as Indian editions at low cost.

N.K. SANYAL

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Contents

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Quarterly

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INSTRUCTIONS TO AUTHORS

School Science is a quarterly Journal intended to serve teachers and students in schools with the most recent developments in science and science methodology. It aims to serve as a forum for exchange of experience in science education and science projects.

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Isotopes In Medicine

A. Nagaratnam

Institute of Nuclear Medicine and Allied Sciences, Delhi

INTRODUCTION

MODERN medicine is the meeting place of many sciences. The methods, techniques and instruments developed by biologists, chemists and physicists are being applied by the clinician in understanding and conquering disease. A supreme example of such an application is the field of nuclear medicine. The availability of radioisotopic techniques to the medical scientist in the past two decades has led to exceptional advances in the field of clinical medicine and research. Radioisotopes have proved to be an extremely valuable tool in the diagnosis of many disorders as well as in therapy. Tracer techniques are giving us deep insight into the problems of metabolism of various substances in health and disease, virus infections, immunology, ageing, heredity, cancers, bionomics of insects and disease-carrying organisms, etc. They have provided us with a better understanding of the site and mode of action of drugs. Powerful gamma radiation sources are being employed for the sterilisation of drugs, needles, syringes, catheters, scalpels, dressings, etc. The newer techniques of neutron activation analysis promise to be of great use in forensic medicine. For instance, it has recently been shown by activation analysis of the hair of Napolean that he was poisoned by arsenic given over a period of time in small doses.

THE TRACER TECHNIQUE IN CLINICAL INVESTIGATION

By far the most important medical application of radioisotopes are their use as tracer atoms inside the body. Chemically a radioisotope is no different from its normal counterpart. Thus so far as the human body is concerned, the biochemical and metabolic behaviour of the radioisotope is similar to that of the stable atoms of the same element. But the atoms of the radioisotope act like miniature X-ray apparatus, the radiations from which can be detected and measured by suitable instruments (like Geiger counter or scintillation counter). Thus they act as labels or tracers which help us to follow the course of the normal element in question. By the use of gamma emitting isotopes, the activity inside the body can be detected by instruments located outside (*in vivo* counting).

A tracer must be introduced in low enough amount as not to interfere with normal metabolism. This is generally the case. For instance, the weight of radio-iodine even as a tracer dose for thyroid function studies would be only about 10^{-10} grams and would thus not at all interfere with the normal metabolism of iodine. Further, it is important that the radiation dose that the subject receives as a rasult of the tracer study should be reduced to a

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minimum. Fortunately, today, by a combination of suitable isotopes and sensitive instrumentation it is possible to conduct any type of tracer investigation without subjecting the patient to significant doses.

With the availability of a variety of radioisotopes from the Apsara and Canada-India reactors at the Atomic Energy Establishment, Bombay, the last few years have witnessed a great advance in radioisotopic work in the biomedical and clinical fields in our country.

Types of Tracer Investigations

The types of clinical investigations for research or diagnosis using radioisotopes may be classified broadly as: (i) isotope dilution; (ii) circulation; and (iii) localisation studies.

The dilution technique is used to measure the volume of a compartment of the body or the total amount of substance present in such a compartment. A known activity is injected into the compartment and allowed to mix thoroughly. A diluted sample is then withdrawn for assay. From a knowledge of the total activity injected and the activity and volume of the diluted sample, total size of the compartment may be estimated. An example of such an analysis is the determination of blood volume, which is described subsequently. Circulation studies help trace the course of radioisotope in time and space inside the body. Localisation studies give information on how a radioisotope is concentrated and distributed in any particular organ.

We will next briefly review the areas where radioisotopes have proved their worth as diagnostic aids.

Radioiodine in Thyroid Disorders

The thyroid is a small gland situated in the neck region. It manufactures a hormone, thyroxine, which controls normal growth and the maintenance of mental and bodily functions. If it is overactive (hyperthyroidism) the person has a rapid pulse, tremors, loss of weight, restlessness, etc. If underactive (hypothyroidism) he has dry hair, obesity and sluggishness of all mental and bodily functions.

Iodine is an essential constituent of thyroxine. We normally get as much iodine as we need in our drinking water and foods. However, if there is a shortage of iodine, the gland grows to an enormous size in its attempt to grab all the iodine it can (goitre).

Thyroid function can conveniently be assessed by giving the subject a small capsule containing a tracer dose of radioiodine (I^{131}) and measuring the extent of uptake of I^{131} by the thyroid after a definite time. This is done by a suitably placed scintillation counter near the neck. Such a 'radio-

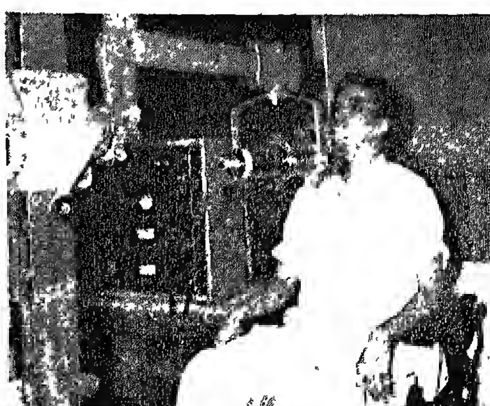

Fig. 1. Radioiodine uptake by thyroid being measured with a scintillation counter

iodine uptake test' tells whether the thyroid is normal, over- or under-active. The

Fig. 2. Woman with goitre (left). Map of India showing endemic goitre regions (right)

average uptake at 24 hours after an oral dose is about 40 per cent of the original dose in normals, in hyper-thyroidism over 70 per cent and in hypothyroids under 30 per cent.

The Himalayan range inclusive of the foothills and adjacent areas are well known for a high incidence of goitre. Goitrous patients from the endemic areas are being investigated with the aid of radioisotopic and other techniques. The results of the investigations have been interpreted as an indication of iodine hunger of the gland, probably caused by iodine deficiency in the soil and water. In some families a genetic component appears to be perpetrating goitre, along with iodine deficiency. It seems that much can be done to prevent goitre by ensuring an adequate supply of iodine in the diet of the population of the endemic areas as a prophylactic measure. (The Chinese are said to have cured goitre, as far back as 3000 years by eating burnt sponges from the sea, which are a rich source of iodine.)

If we want to know how the iodine is distributed in the gland, whether the gland

Fig. 3. Thyroid gland being scanned by cliniscanner

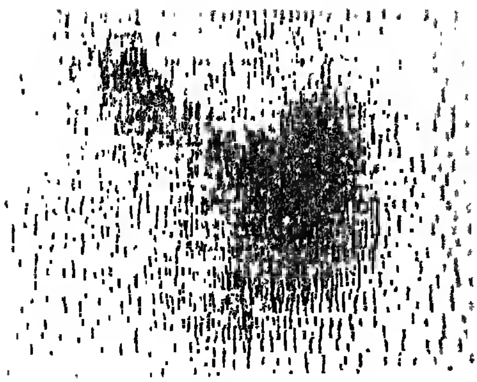

Fig. 4 a

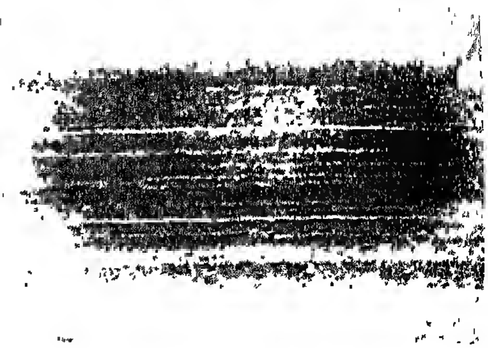

Fig. 4 b

Fig. 4 a and b. Scan shows pattern of radioactivity concentration in thyroid tissue

is large or small, whether some parts of it are more or less active than normal, a scan of the thyroid is done with an instrument known as scanner, after a tracer dose is given. The whole of the neck area is scanned from side to side stepwise with scintillation counter which is 'collimated' to see only a narrow region. As the counter scans the area, the activity seen by it at every part is automatically recorded on a special recording paper. At the end of the scan, we get a picture of the functioning thyroid tissue, aberrant thyroids, over- and underactive nodules, etc.

Cardiac Function

In heart function tests, a small dose of human serum albumin tagged with radio-iodine is injected into a vein while a detector

Fig. 5. Cardiac function studies being carried out by injecting I^{131}-tagged human serum albumin and recording radioactivity over the heart

placed over the heart continuously records the radioactivity in the heart region. As the bolus of injected radioactivity reaches the heart, there is an immediate jump in the record of the heart activity which then falls down as the blood is pumped from the heart to the lungs. With the return of the oxygenated blood from the lungs back to the heart there is a second rise in the curve, followed by a fall as the blood is pumped out. Such a 'radio-cardiogram' shows the changes in action of the heart chambers and gives information on the pumping capacity of the heart, cardiac insufficiencies, etc.

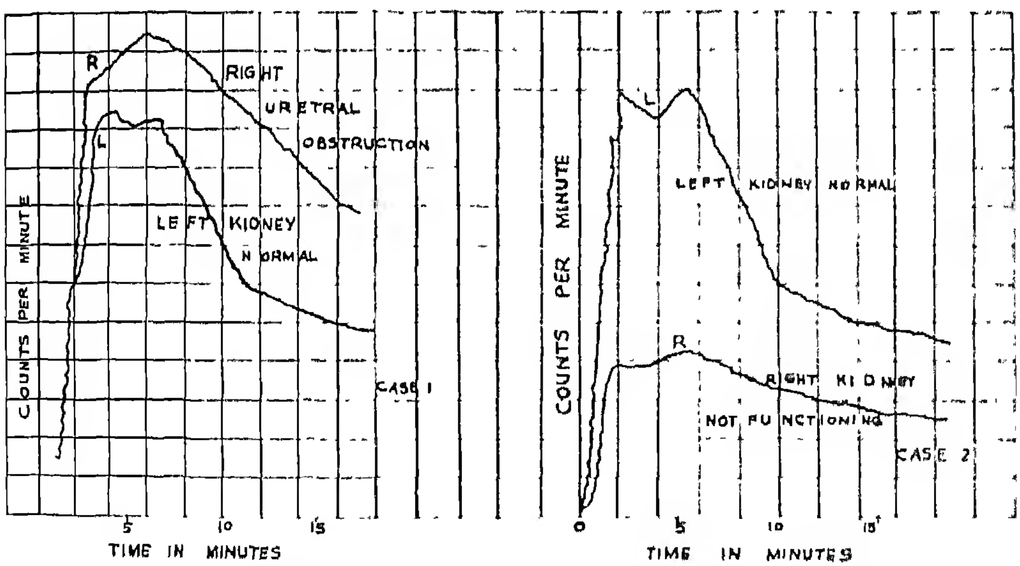

Fig. 6. Illustration of radioisotope renograms for kidney function studies

Kidney Function

Kidney function studies can be carried out very simply by the use of radioiodine-labelled hippuran, a substance which is taken up by the kidneys extremely rapidly from the blood. Two scintillation counters are positioned at the back of the subject, one to view each kidney. A small quantity of the labelled hippuran is injected intravenously and the variation of activity over each kidney is simultaneously recorded by automatic recorders. An examination of the two records immediately reveals the presence of any abnormalities of function.

Liver Function

The dye Rose Bengal is selectively taken up by the liver. Liver function may therefore be assessed by injection of I^{131}-tagged Rose Bengal. In normals the liver uptake (as determined by a suitably positioned scintillation detector) rises to a maximum of 5 minutes after injection and then falls. If liver function is impaired maximum uptake is low and falls only slowly. Where necessary, the liver may also be scanned to locate non-functioning liver lesions which are usually cancerous.

Circulation Studies

Whether blood flow to all parts of the body is normal may be simply determined using radiosodium (Na^{24}). A small amount of Na^{24} is injected into an arm; the time taken for the activity to appear in the leg (which is about half a minute in normals) reveals the state of the flow; the exact location of a block, if any, can also be pinpointed. Circulation times are altered in some disease conditions.

Investigation of Blood Disorders

For determination of blood volume a known small amount of radioiodinated human serum albumin is injected intravenously and sufficient time (15 minutes) allowed for this to mix uniformly with the entire volume of blood in the body. A sample of blood is then withdrawn and its activity determined. By this means the degree of dilution of the original activity by the blood pool can be determined and this gives immediately the blood volume.

To determine the red cell mass, a small amount of the patient's blood is withdrawn and incubated for about half an hour with radioactive chromium in the form of sodium chromate. This labels the red blood cells with Cr^{51}. At the end of this period the activity of the tagged blood is determined and it is then injected back into the patient. After a sufficient time for mixing, a sample of blood is withdrawn and assayed for radio-activity. From this it is possible to estimate the red cell mass.

The same test can also be used for the determination of red cell life. This is useful in the diagnosis of different types of anaemia as well as for detection of blood loss in cases of gastrointestinal bleeding. The average life of a normal red cell is about 120 days, after which it goes out of circulation. Now when a red cell dies the Cr^{51} does not attach itself to another cell but passes out of the body. So the rate of decay of activity in blood measures the survival time of the red cells. Half-life of Cr^{51}-labelled red cells is about 26 days in normals while it is considerably reduced in leukaemia or anaemia.

In certain types of anaemias, it is important to determine the site of destruction of red cells. If the spleen plays an active part in red cell destruction, then splenectomy will help. Such information can be gained by counting over a period of several days the build-up of activity over the spleen and liver.

Labelled iron (Fe^{59}) has also found great use in the study of blood disorders. Iron is an important constituent of haemoglobin in the red cell. Iron deficiency causes anaemia. When a tracer dose of Fe^{59} is given intravenously, it goes slowly from blood to the bone marrow. In the bone marrow the iron is incorporated into the red blood cells, which come out into the circulation after a few days. Most of the red cells finish their life in the spleen. Tracer studies have shown that unless fresh supplies of iron are taken in food and drink, iron from the dead red cells is not excreted but appears again in the bone marrow to take part in further cycles. The rate of radioiron turnover has proved to be a good diagnostic index in the investigation of polycythaemia (overproduction of red cells), different types of anaemias and iron deficiency.

Vitamin B-12 is necessary for the production of normal red cells. In the presence

of an 'intrinsic factor' produced inside the body, it is absorbed in the intestine. If the intrinsic factor is not produced, the vitamin is not absorbed and anaemia results. A similar condition results if the vitamin is absent from diet (nutritional deficiency anaemia) but this condition is easily corrected by supplementing the diet with vitamin B-12. By giving a test dose of Co^{58}-labelled vitamin B-12 and studying the percentage absorption, the status of the patient can be assessed. If the deficiency is due to lack of intrinsic factor the absorption is very low, while if it is due to dietary deficiency the absorption is normal or high.

Diagnosis of Tumours

Certain radioisotopes are selectively taken up by growing tumours. This property has been applied in the detection and delineation of tumours of the skin, eye, testes and breast, using radiophosphorus (P^{32}).

For the localisation of brain tumours, the most suited are certain positron emitters like radioarsenic (As^{74}). A positron, as it comes to rest, is annihilated by combining with an electron; this process is accompanied by the emission of two gamma rays in opposite directions. These are detected by two counters mounted on opposite sides of the patient's head, so arranged that a count is registered only when both counters detect gamma rays simultaneously. By this means all background is virtually completely suppressed and exact localisation is possible,

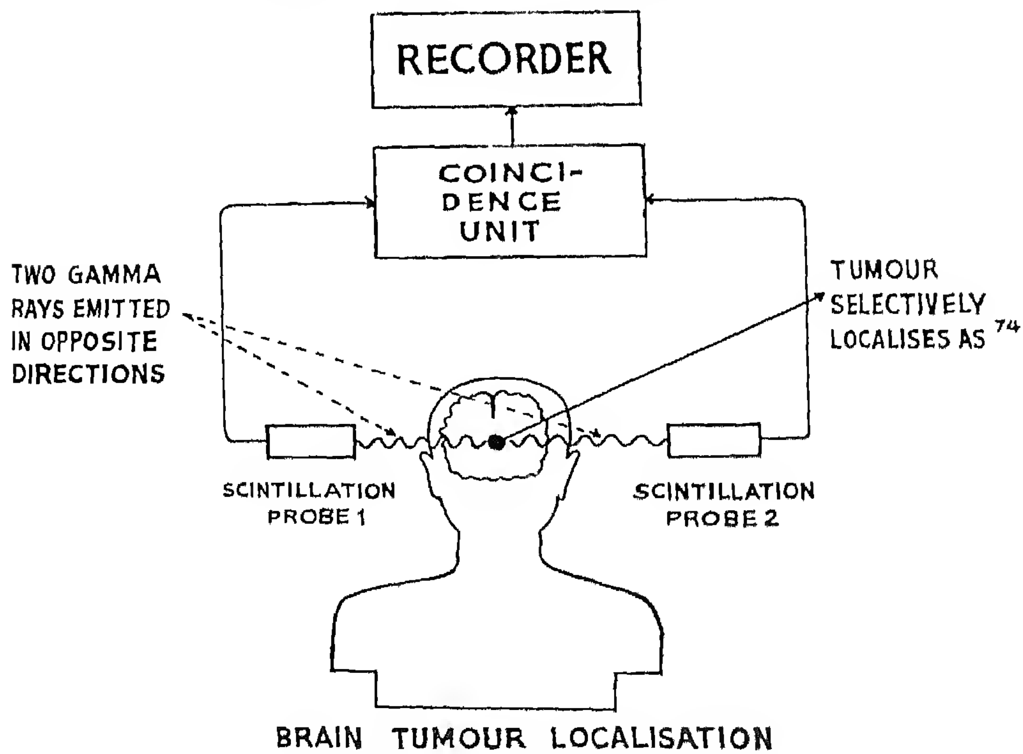

Fig. 7. Localisation of brain tumours using radioisotopes

by scanning the patient's head completely with the aid of coincidence counters.

Fig. 8. Patient drinking radiomedicine

Lung Function

Lung function can be assessed by the use of suitable radioactive gases (like Kr^{85}, Xe^{133}) which the patient is made to breathe with oxygen, and recording the radioactivity over each lung by suitably placed external counters.

RADIOISOTOPES IN THERAPY

Today everyone is familiar with the use of radioactive cobalt for treatment of cancers. Cancer consists in the uncontrolled multiplication of certain cells. Since cancer cells are multiplying much faster than cells of surrounding healthy tissue, it is found that they are more susceptible to be affected by radiation and this property is used in radiation treatment. With modern reactors Co^{60} pellets can be obtained whose strength is equal to that of several

Fig. 9. Patient suffering from thyroid disease. (a) before treatment (left) (b) after treatment with radiomedicine (right)

pounds of radium. In fact, Co^{60} has been called the poor man's radium. Apart from the price, there would not be enough radium in the world to do all the therapy work now being done with Co^{60}. This isotope emits energetic gamma radiations which can penetrate into the body and irradiate even deep-seated tumours. The idea is to give a lethal dose of radiation only to the malignant tissue while sparing as much as possible the surrounding healthy tissue. Many techniques are now available for doing this. Cesium-137, a fission product obtained in the operation on nuclear reactors, is partly replacing cobalt-60 in some teletherapy applications.

I^{131} has been used extremely successfully for the treatment of hyperthyroidism. A large dose of I^{131} is given which concentrates in the thyroid. The radiations from the radioisotope destroy part of the overactive thyroid and brings its function back to normal. Radioiodine therapy has largely replaced surgery of the thyroid, thus obviating discomfort, hospitalisation and attendant risks of surgery. I^{131} has also found application in the treatment of some forms of thyroid cancer.

Those suffering from congestive heart failure and angina pectoris, i.e., pain originating from the heart, and not responding to conventional treatment, can be given considerable relief by radioiodine therapy. This reduces thyroid function and consequently the metabolic needs of the body; work on the heart is reduced and the impaired heart

Fig 10 Parkinsonism patient: (a) before treatment (left). Patient has marked rigidity of limbs. (b) after treatment (right) Note improvement in rigidity. Patient able to smile and use hands freely

is then able to meet the reduced circulatory needs satisfactorily.

Parkinsonism is a crippling disease leading to extreme regidity of limbs, tremor, postural disturbance, etc. The general method of treatment, giving limited benefit, includes medical and physiotherapeutic measures and in some cases neurosurgical treatment. Recently by radioiodine therapy strikingly helpful benefit has been obtained in the relief of rigidity and moderate alleviation of tremors in many cases of Parkinsonism.

Polycythaemia vera is a disease caused by overproduction of red cells in the bone marrow and other sites. Radiophosphorus therapy is now the treatment of choice for this condition. A single course of therapy induces remission lasting several years. The P^{32} inhibits the increased production of red cells by destroying part of the bone marrow which manufactures these cells. P^{32} has also found limited application in the treatment of certain types of leukaemia (cancerous overproduction of white blood cells).

Recurrent effusions in pleural and peritoneal cavities arising from malignant diseases used to be treated by repeated drainage. This, apart from the great discomfort to the patient, often leads to loss of body proteins. Instillation of colloidal radiogold (Au^{198}) into these cavities has been used with marked success in such cases in ameliorating distressing symptoms. Direct implantation by surgery of radioactive materials (like Ta^{182} wires or Au^{198} seeds) into tumours for the desired length of time to give a suitable radiation dose to the tumour with sparing of surrounding tissues is a standard technique these days. External beta radiation from radiostrontium (Sr^{90}) incorporated in applicators has been used for the treatment of certain eye and skin disorders.

NUCLEAR MEDICINE AN INTEGRATED DISCIPLINE

Successful implementation of a nuclear medicine programme demands the close integration of several disciplines. Apart from the nuclear medicine specialist, the health physicist, the electronics engineer, trained technicians and nurses have all to work in close liaison. The instrumentation has to be looked after properly by trained technicians under the supervision of the electronics engineer. The health physicist provides the facilities for safe working with radiation sources and ensures that the patient, the doctor, the nurses and the ancillary staff are not subjected to unnecessary exposure from external or internal radiation sources. He also trains the technicians and nurses in the safe handling of radiation sources, which includes in this case patients given large doses of radiomedicines and their excreta, etc. By this close integration the new and rapidly growing science of nuclear medicine has been able to play a vital role in conquering disease.

Social Insects—II. Bees and Wasps

P. Kachroo

Indian Council of Agricultural Research, New Delhi

BEES

BEES live in permanent communities. Their body has a marked waist. The head and thorax bear branched feathery projections which help them in collecting pollen from flowers. These projections cannot be seen by the naked eye but this character distinguishes bees from wasps. The honey bees have three types of individuals: males (drones), females (queens), and sterile females (workers) (Fig. 1). It is interesting to note that distinction between queens and workers is caused by the different food with which the larvae are fed. After hatching, the brood are fed alike for the first four days. Later, some i.e., the would-be queens are fed with richer food throughout their growth. They are finally provided with cells which are larger and better ventilated.

The males are large, stingless and big-eyed. The queen is smaller than the male. It continues to fertilize her eggs for the rest of her life which is three to four years. The workers are much smaller but have larger brains. They gather pollen in basket-shaped hind thighs and also possess the honey making and wax secreting organs. The egg-laying organ is developed and used as a weapon (sting) in the workers. After use, it is withdrawn; but if the bee is hastily shaken off, the sting and other organs are torn from her and she dies.

The adult bee feeds upon the nectar of flowers. Its larvae are fed upon the pollen of flowers mixed with honey, the latter being a substance made in the body of the bee out of nectar gathered from the blooms. The larvae of cuckoo-bees, before beginning to eat the stored honey, devour the eggs or larvae of another species of bees in whose nest they have earlier been placed!

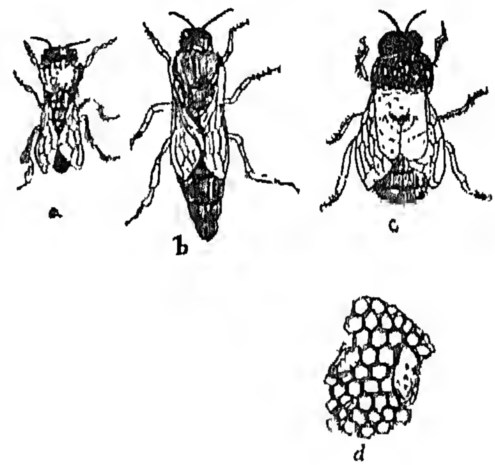

Fig. 1. Bees: (a) worker, (b) queen, (c) drone, (d) comb—a portion of normal cells and two large queen cells

Community Life

The permanent social community of the bees is called the hive. Here, each individual does its share of duties involved in the community life. However, communities of bees differ from those of ants in certain respects. The bees in the wild state build their home in a hollow tree. Under domestication, the hive is designed by man to enable him to rob the honey without killing all the bees. The 'comb', with which the hive is furnished, is

built of wax prepared in the bodies of the worker-bees. Such an architectural symmetry is not met with in the ants' nest. In each hexagonal separate tubular cell is reared a single bee from the egg to the adult stage. Normally only one queen bee lives in a hive at a time. The hive is stored with garnered foods but the ants' nest does not usually store food. The bees fly out to gather food, but the ants walk for the same.

A new hive is founded more or less in the same way as that of the ants. In May, i.e., summer, when the hive becomes overcrowded, the community needs a new queen. At this time, the Queen Mother is led round the queen cells by her attendant workers and she is made to lay an egg in each cell. The larvae hatching from these

Fig 2 Honey bees : a swarm clustered on a branch

eggs are supplied with special food or 'royal jelly' throughout their life. In about 18 days the first of the bees developed in a royal cell is crowned as the heir-apparent. She is the maiden queen. Before she leaves her royal apartment, the Queen Mother leaves the hive accompanied by a swarm (about 30,000) of faithful bees, mainly workers. The swarm flies for some time, then the queen alights and is wrapped in a protecting mass of bees as big as a water-melon. The bee-keeper, if he is lucky, collects them in this condition in a 'skep' and brings them home to a new man-made hive.

Immediately, the workers get busy in building the comb. They pluck the flakes of wax from between the segments of their bellies, mould it in their jaws, and build the exact cells they need. The wax is made from the honey which the workers carry in their crops while leaving the mother hive. The cells are of a standard size, those in the centre are the nursery cells for the young workers, those around them are the storage cells for honey and pollen. Drones are housed in larger cells and the still larger cells are the royal apartments meant for the future queens Soon after the new hive is ready the routine life begins. The egg fertilizing capacity of the queen can be increased or diminished by the amount of food given to her. In winter, she does not lay eggs but feeds herself on the storage cells.

Efforts are made to collect new stores and put these into the new comb as it is built. Each cell containing a larva is looked after well before it pupates; the cell is sealed up by the workers with a lid of pollen and wax, the latter is eaten by the emerging bee to get out. Ventilation in the hive is provided by a novel method; the young workers, who have yet not flown, steadily fan with

their wings so as to make a current of fresh inflowing air. This fanning also serves to evaporate the surplus water from the honey. The entrance is guarded by guardsman to stop intruders, particularly robbers from other hives. Some intruders which cannot be stung (such as ants) are fanned away from the entrance. The dead bees are removed by outgoing workers and dropped at a distance. The comb is repaired with a special glue which is obtained from resinous buds and twigs and secreted by workers. This is additional work for the workers who have also to collect nectar and pollen.

Incoming bees report to their fellows the discovery of any rich source of food by a dance of triumph. The scene of the dancing bee tells others what kind of flower they must seek, and once a bee has found nectar the colour of the flower helps to guide her back to it.

In the old hive, soon after the swarm departs, interesting events take place. The young queen emerges from her cell and at once dashes towards the cells in which her sister princesses are still in the pupal stage. She tears open their cells and stings them to death. How awful, yet true! Sometimes she is prevented from this murderous act by the workers and a second princess is allowed to emerge. She leads another swarm from the old hive. Thus, only one queen can stay in a hive. When the princess is the only female in the hive, she mates with a drone, returns to the hive as a feeds queen. Till she is fertile the workers do not pay any attention to her and she feeds herself at the comb. Before leaving the hive for her 'marriage' the would-be queen flies round and about the entrance to learn her way home.

The queen lives for three to four years and her end is a tragic event. As soon as it is noticed that she is no longer active, her escort ruthlessly crushes (not sting) her to death; or she is allowed to be killed by a daughter princess. At the approach of winter another tragedy betakes the hive: there is a massacre of unwanted drones due to shortage of food. When they return to the hive hungry after their usual short unhurried flight in the sunlight, they are denied admittance and those still in the hive at the moment are attacked and thrown out. Drones still at large while the massacre is on die of cold and starvation after crawling helplessly about for a day or two.

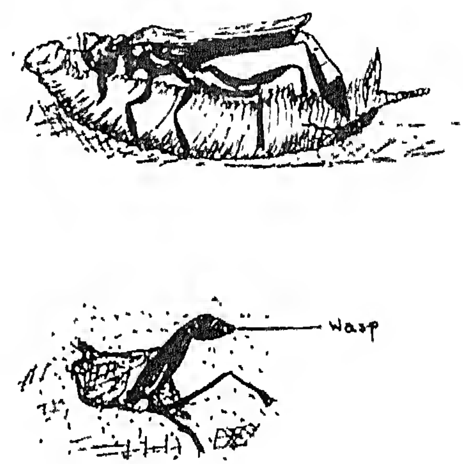

Fig. 3. Wasps

TRUE WASPS

True wasps are social insects living in large colonies and producing males and females and a large number of sterile females or workers. Their social life is seasonal since the colony lasts only for a single season. The young fertilized females (queens) are the only survivers which live through winter. Each of the queens builds a new nest in the spring.

The adult wasps live on plant food, mostly nectar and sweet liquids (especially ripe fruits and jams). The young brood is fed mostly on insects captured by adults and chewed up by them before being fed to the larvae.

The mated females, like those of the ants and bees, fertilize their eggs for the rest of their lives. They hibernate during the cold weather by hanging by the jaws to curtains or other rough surfaces in some secluded spot (often in houses or sheds, in a hole in a wooden fence or a crevice in a tree). The dormant queens awake in the late spring and start constructing a nest alone. They try to find a hole under the roots of trees or shrubs and there begin to excavate a cavity, large enough to build the first comb of their nests. They do not have wax but build with wood pulp paper, filings of wood shaved from any wooden surface with their jaws and made into paper with the wasp's own saliva. The comb resembles in shape the bee hive only in that the cells are hexagonal tubes, set one beside the other, and each destined for one egg and its development into an adult wasp. The top layer is the first to be built. It has few cells to begin with and forms a solid hanging rod. It sustains the whole nest when completed. Later, layers are built below the first, each hanging from the one above it by similar rods and forming a platform upon which the wasps can walk with access to the open ends of the cells above their heads. The comb when completed is surrounded and enclosed in a very thick envelope which is constantly enlarged.

The queen after having built parts of the comb lays an egg in each cell and when the larvae hatch out, she feeds them all on countless caterpillars, flies, and other insects which she chews up and deals out from her own tongue to her hungry brood. While the larvae grow, she goes on completing their cells. Before they pupate, they themselves close the lid of the cell. Through it, they eat their way out as adult wasps. From egg-laying to emergence of the adult, it takes about a month

The first eggs develop into workers and when they are strong enough they relieve the queen of her manual duties. She at last rests from foraging and building and gives herself exclusively to egg-laying. For a month more the nest increases and prospers and then manual comb is built with larger cells for the production of male and female wasps. With this increase in population, insect food for the brood begins to run short and it is hard for the workers to collect nectar for themselves. Besides, as their own life is drawing to a close, they set about a reign of terror; the unhatched larvae are thrown away from their cells to the bottom of the nest hole and allowed to die there. Soon winter sets in and the whole population of the nest dies of cold and starvation. The few mated queens left to survive start fresh nests the following year.

The Role of Catalysts in Chemical Manufactures

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A world consumption of 120,000 tons a year may seem a great deal for substances which, one is taught, emerge unchanged from the chemical reaction. The author explains why these curious substances are so vital in industrial operations.

A CATALYST is involved at some stage or other in the manufacture of almost all chemical products today, from margarine to artificial textiles, from chemical fertilisers to plastics and petrol. Most industrial catalysts are man-made materials but some, such as enzymes, also occur in nature and play an important part in biochemical processes. But in this article I shall discuss neither these natural catalysts nor those which act in solution (the so-called 'homogeneous' catalysts). What I do propose to discuss is the field to which most industrial catalysts belong, that of 'heterogeneous' catalysis, where a solid assists in converting gaseous or liquid reactants into a required product.

At ordinary temperatures and pressures many pairs of substances—for example, pertroleum hydrocarbons and steam, or nitrogen and hydrogen show little inclination to combine. If we raise the temperature, and perhaps apply extremely high pressure too, they can often be persuaded to unite, but these methods are usually prohibitively expensive on a large scale. However, by introducing a third substance, the catalyst, which may be as ordinary as metallic nickel or iron, chemical reaction can often be induced to take place at reasonably low temperatures and pressures. Normally, only small amounts of a catalyst are needed because it is not consumed in the reaction (and therefore does not appear in the product unless something goes wrong).

Just how important catalysis has become to the chemical industry can best be illustrated by means of figures. The world consumption of solid catalysts is about 120,000 tons a year, valued at £40 million—pretty imposing figures for something 'not consumed in the reaction'. The petroleum industry alone uses 100,000 tons of catalysts, valued at £25 million.

What they can do. In extreme cases catalysts appear to make reactions take place which otherwise would not occur at all. The fact is, however, catalysts do not achieve the impossible, and they break no chemical or thermo-dynamic laws. They function simply by making chemical reactions go faster. Reactions which appear not to take place at

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ordinary temperatures in the absence of a catalyst do, in fact, occur—but so slowly that no change is detectable in a reasonable time. With a catalyst present, however, the rate of combination is so increased that the reaction can be observed to take place.

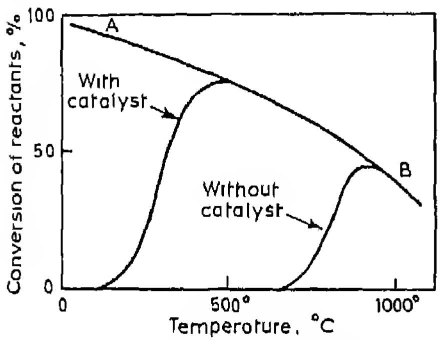

Fig. 1. The effect a catalyst can have on a reaction. The line AB is the conversion that is theoretically possible; this is obtained at a lower temperature when a catalyst is present

Time is the crucial factor, of course. A catalyst takes a reaction near to completion at technically acceptable temperatures and pressures, in a time that is commercially attractive. Figure 1 shows how far one sort of chemical reaction can go at different temperatures The line AB represents completion; it is the conversion of reactants which, whether a catalyst is present or not, could theoretically be obtained at various temperatures given infinite time; that is, the equilibrium conversion. The other lines show the conversion that is obtained in a realistic time, with and without a catalyst. Plainly the catalyst initiates and completes the reaction at a lower temperature where, in this particular example, a higher yield is also obtained.

Catalysts are found to be very specific in their functions, each being suited to a particular type of reaction, or even to a specific reaction. The iron catalyst used for the synthesis of ammonia cannot be used in place of the vanadium catalyst which catalyses the oxidation of sulphur dioxide. This selective behaviour can be turned to advantage. Often the reactants can form several different products, but by choosing an appropriate catalyst the desired product can be obtained at the expense of the others.

For a particular reaction and product the right chemical composition has to be found for the catalyst, and this is complicated by the fact that impure substances are often better catalysts than pure ones. The 'impurities', usually added deliberately in amounts up to perhaps 5 or 10 per cent, are called 'promoters'. Some catalysts contain more than one promoter, and at present the best ones are found only by trial and error.

Catalysis is a property of the solid surface and the effectiveness of some catalysts is directly related to the area of their surface. Many catalysts are highly porous and their surface area may be very large—100 square metres a gram (40 square miles a ton) is a common figure. Careful control during manufacture of the catalyst and in some cases the addition of a promoter are needed to secure so large a surface. Sometimes the catalytic material itself is present only in small amounts dispersed throughout a non-catalytic solid of high surface area, such as carbon, which is known as a support or a 'carrier'.

Catalysts might be expected to last for ever because they are not consumed in the process, but in practice they eventually cease to function. Some will last for several years, others only for a few weeks.

A catalyst may simply disintegrate, or high temperatures may slowly reduce the surface area (a process which can be retarded by the addition of promoters)

Catalysts are also very sensitive to impurities, some of which—the promoters—are beneficial, whereas others are detrimental. The latter, known as 'poisons', can include such elements as sulphur, chlorine and arsenic, when associated with certain catalysts. Obviously the 'poisons' must be eliminated from such a catalyst during its manufacture, and removed from the reactants before these come into contact with it.

Another cause of failure is blocking up of the fine pores with a by-product of the main reaction. Here, the obstruction can often be removed—for example, by roasting it in air, in the case of carbon contamination.

How they work. Having considered what catalysts are and what they do, let us now see how they function. That theory lags behind practice in industrial catalysis is no reflection on the fundamental research effort, which has been considerable in the last 20–30 years. Rather it is indicative of the complexity of catalyst systems.

We have seen that catalysis is brought about by a solid surface. The atoms at the surface of any solid are in a special situation, for they are not completely surrounded by other similar atoms; the surface therefore has properties very different from those of the solid in bulk.

In order to react, molecules must come within a certain distance of each other, and to do so they need to possess an energy that exceeds a critical value, the so-called 'activation energy'. If its value is high, as it may be in an uncatalysed reaction, very few molecules will react, then we have the reaction I referred to earlier which 'does not take place'.

According to what we might call the classical theories of catalysis, a catalyst lowers this energy barrier by providing the reactants with an easier reaction path The reaction can now take place in steps, each of which involves an activation energy lower than that of the

(a)

(b)

(c)

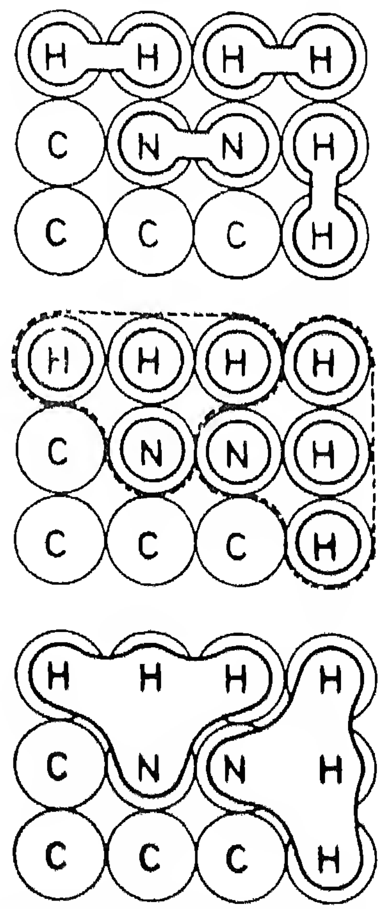

Fig. 2. Diagram showing what may happen on the surface of a catalyst: (a) adsorption of molecules on the catalyst C, (b) break-up of the molecules and (c) recombination of atoms

uncatalysed reaction. More molecules now have the necessary energy, and so more participate; in other words, the reaction rate has been increased. The sequence the reaction follows is probably, first, adsorption of the reactant molecules on to the catalyst, where they combine or react with other gaseous molecules to form the desired molecules, which then leave the surface, allowing the cycle to be repeated (Figure 2).

Many elegant experiments have demonstrated conclusively that adsorption of one or all of the reactants is an important part of catalysis. The adsorption is strong, involving chemical bonds, but it takes place more readily on some parts of the catalyst than others. This discovery has led to the concept of 'active' centres—areas which are held responsible for catalytic activity even though they represent only a very small proportion of the total surface of a catalyst.

The sensitivity of catalysts to small amounts of poisons is evoked as evidence for the existence of the active centres, which are believed to be associated with defects or irregularities in the surface of the catalyst's crystal lattice. At these dislocations or corners in the lattice the valency or combining forces of the surface atoms will be available for strong adsorption of the reactants. The defects in the crystal structure may arise through the presence of impurities, which explains of course the action of some promoters.

This picture is relevant for many kinds of catalyst and, although it has been faulted by recent experiments, it still forms a good foundation for modern theories. It can be developed to take into consideration the geometric arrangement of the atoms in the solid surface. Some reacitons are only catalysed by metals having an atomic spacing that corresponds to the interatomic distances of one of the reacting molecules. Adsorption of the molecule is thus assisted, and such a catalyst will be specific to reactions involving that particular reactant. The geometric theory can be pushed too far, but it leaves us with the valuable concept that a reactant molecule can actually be positioned on the catalytic surface, and thus favourably located in relation to neighbouring adsorbed molecules.

The modern theories, developed since the second World War, which consider the electronic structure of the surface atoms do not conflict basically with the classical ideas of active centres and surface geometry. Rather they attempt to explain their assumptions. There is undoubtedly some relationship between catalytic activity and a substance's electronic properties. The availability of electrons at the solid surface or the ability of the surface to receive electrons clearly must affect catalytic activity, because adsorption of the reactants, which involves chemical bonds and electrons, is a vital step in catalysis.

Electrical conductivity is influenced similarly by this same availability of electrons, and we find that catalysts can be classified very broadly by their conductivity. The catalytic metals (such as iron, nickel and platinum) which are good conductors are often found to catalyse reactions involving hydrogen. Many of these metals have similarities in their electronic structure. Some oxides and sulphides, such as the oxides of nickel, zinc and copper, classified as semiconductors because they have a small conductivity, catalyse reactions involving oxygen. Other oxides such as silica, alumina

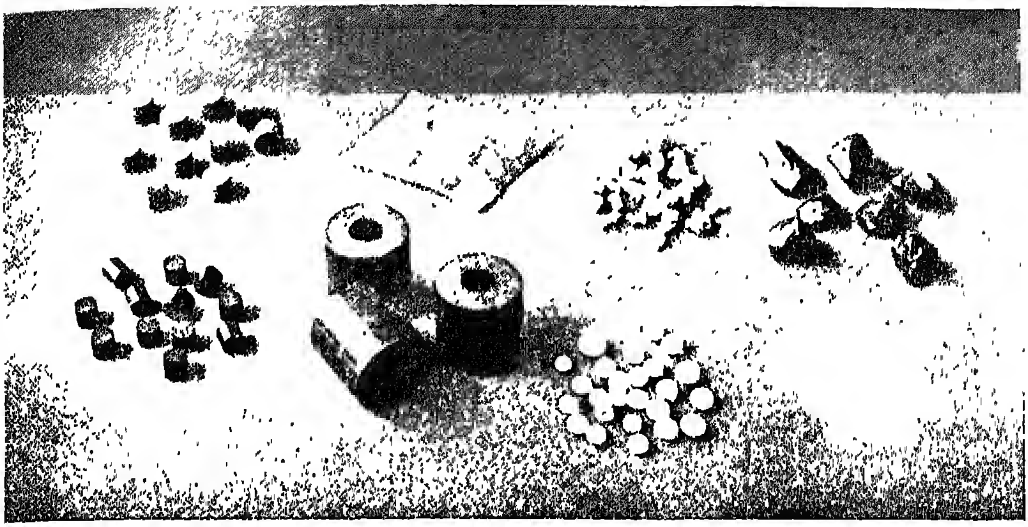

Fig. 3. Shapes and sizes of industrial catalysts. Back row, left to right: vanadium silica pellets, platinum-rhodium gauze, silver granules and iron pieces. Front row, left to right: zinc chrome pellets, nickel alumina rings and alumina-silica beads (large and small)

and magnesia are electrical insulators, and these catalyse reactions involving water.

For completeness I should mention a fourth group of oxides which lies outside this electronic classification, the so-called 'acid' catalysts. They include the alumina-silica complexes which catalyse reactions involing hydrocarbon molecules by breaking up or 'cracking' them, or by transferring parts of the molecules, reactions known as isomerisation and polymerisation.

How they are used. Let us now consider briefly the use of catalysts in industry. In developing a new process all of the properties and limitations of catalysts have to be borne in mind. In the search for a new catalyst one is guided both by experience and by the theories which we have discussed. Many laboratory and large-scale tests will be made to single out the 'best' catalyst, and to establish the rate of reaction and the yield we can expect, so that the amount of catalyst, the size of reactor, the process conditions, and so on can be settled.

The shape and size of the reactor can vary enormously in practice, depending on such considerations as whether the reaction is fast or slow and whether it evolves heat. Thus catalysts can be used as wide, thin layers, as deep beds, or as a solid suspended in a liquid reactant. The catalysts themselves, too, vary widely in shape and size from large irregular lumps or shaped pellets, pieces, granules or fine powders to strips of metal and woven wire gauzes. A few of the catalysts used in chemical engineering are shown in Figure 3. They include catalysts which are milestones in the progress of industrial catalysis and which illustrate some of the features I have discussed.

One of the first large-scale applications of catalysis was in the oxidation of sulphur dioxide in the manufacture of sulphuric

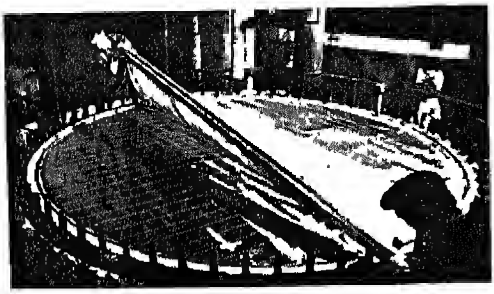

Fig 4. New platinum-rhodium guaze being laid on a rigging of string in an ammonia burner at Shell's nitric acid plant, Shell Haven

acid, an extremely important 'raw material' for many other manufacturing processes. A vanadium catalyst is now employed as it is less sensitive to poisons than the platinum catalyst used when the process was first introduced around 1900 The vanadium catalyst, which is in the form of cylindrical pellets (Fig. 3), contains potassium to improve its activity, and silica which functions mainly as a mechanically strong carrier.

In 1908 the process for the catalytic oxidation of ammonia for the production of nitric acid was brought into use. The reaction is very fast, being complete in about one-hundredth of a second, so that it needs only a thin layer of platinum rhodium wire gauzes (Fig. 4) as a catalyst. Another rapid reaction, the oxidation of methanol to formaldehyde, uses a layer of silver granules (Fig. 3).

The next milestone was in 1913 when the high-pressure synthesis of ammonia was introduced. It was the first process to be evolved by proper application of thermodynamic principles, and the catalyst was the first to demonstrate the value of promoters. The catalyst is basically unchanged to this day—iron containing several promoters such as potassium, alumina, magnesia and other oxides, each having its own job to do; one increases the surface area, another enhances the activity of the iron surface, and others protect it from gaseous impurities It is one of the few catalysts made by fusing the ingredients together, producing the hard pieces shown in Figure 3.

The converter in which it is used as a deep bed is a heavy steel forging, shown in Figure 5.

The high-pressure process for the synthesis of methanol (methyl alcohol) from hydrogen and carbon monoxide followed in 1923, and used a pelleted catalyst (Fig. 3) of zinc oxide and chromium oxide; the latter helped to preserve the surface area of the catalyst. The same two reactants, hydrogen and carbon monoxide, can be made to form hydrocarbons instead of methanol by operating at a lower pressure

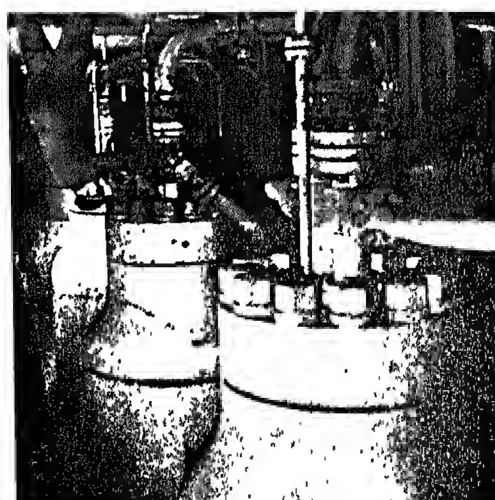

Fig. 5. A battery of converters of an early type for the synthesis of ammonia at high pressure. Each contains a deep bed of iron catalyst

and using a different catalyst, such as cobalt containing other oxide promoters. This process, the Fischer–Tropsch process, came into use in the 1930s.

At much the same time the first plants were installed to react methane with steam to produce hydrogen. Heat has to be supplied, and the catalyst is used at 700°–800° C in heated tubes. The catalyst here is nickel supported on a carrier of other oxides such as alumina and magnesia, and is commonly made in the form of rings (Fig. 3) to keep the resistance to the flow of reactants down to a minimum. This process is the forerunner of the modern one for the manufacture of hydrogen in which the higher petroleum hydrocarbons such as naphtha, which are more readily available than methane in Britain are reacted with steam at high pressure.

The year 1935 saw the introduction of the first catalytic process for petroleum refining, with the introduction of catalytic 'cracking' for the production of petroleum hydrocarbons from crude oils. The catalyst is an alumina-silica mixture, a synthetic version of the natural clays which were used for the earliest processes. Carbon forms on the catalyst and has to be burnt off periodically in a 'regenerator'. The catalyst is usually in the form of beads, shown in figure 3, which are shuttled back and forth between the reactor and the regenerator continuously Sometimes the beads are as small as one-tenth of a millimetre in diameter. Another big advance came in the 1940s with the addition of platinum to this alumina-silica catalyst; this extended its effect on the crude oils and produced higher grade petrols.

I have mentioned but a handful of the catalysts which are now employed by the chemical industry. The average cost of these catalysts is about £350 per ton, a comparatively high figure which reflects the value of the knowledge and attention to detail which goes into their manufacture more than the intrinsic cost of the materials. The amount of these expensive catalysts which are used may seem considerable, but 120,000 tons is very small in comparison with the millions of tons of chemicals for the manufacture of which they are responsible. Catalysts have played no small part in the rapid expansion of the chemical manufacturing industry in the first half of the 20th century. They can truly be said to have catalysed the industry's growth as well as its individual processes.

Bioluminescence

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THE production of light without heat by living things has always appealed to the imagination and excited the interest of mankind. This phenomenon of emission of light visible to the human eye by living organisms is termed bioluminescence, which is often confused with such other terms as phosphorescence and fluorescence. When certain sensitive materials are exposed to radiation rays they will glow in a dark place. Such materials are known as phosphors. Many phosphors continue to glow for extended periods even after the radiation rays to which they are exposed are shut off. This sort of delayed light emission or 'after-glow' is termed the phosphorescence. Fluorescence, on the other hand, is the light emitted by the substance while it is being illuminated by the radiation rays. Basically bioluminescence is chemiluminescence, viz., light for which a chemical reaction supplies the energy.

BIOLUMINESCENCE AMONG PLANTS AND ANIMALS—A BRIEF SURVEY

Bioluminescence occurs both in plant and animal kingdoms. In plant kingdom it is found mostly among certain lowly organised forms like bacteria and fungi; whereas in the animal kingdom certain members of over forty groups are so far known to emit light. Another interesting fact is that among the aquatic luminous representatives, it occurs mostly in those that live in the marine environment. Certain insect larvae and the limpet (*Latia*) of New Zealand are the only freshwater luminous organisms so far known.

The best known of the luminous organisms are certain insects familiarly known as 'fire-flies' or 'glow worms' which even a casual observer would not have missed For thousands of years sea-farers have known that the sea sometimes glitters when some objects strike it. During such occasions every fish that made a slight movement appears to have been outlined with fire and every wave as if it were aflame No wonder such phenomenon was described as 'burning' or 'awakening' of the sea. This awakening of the sea may be due to different reasons, of which the most common one is the occurrence in enormous numbers of a one-celled organism called *Noctiluca*. Though the sea appears from a distance to give out a homogeneous light; if examined nearby in a vessel as sea water, the apparently homogeneous light will seem to come from tiny sparks. These organisms develop in huge quantities at favourable seasons of the year and appear during daytime as red or brown or yellow patches on the sea.

Those who live near a forest area might have seen that a stump or a part of a decaying tree shining at night. This natural glow sometimes called 'fox-fire', has given rise to many hair-raising stories of ghosts and such other supernatural beings. This glow is due to the ramifications of thread-

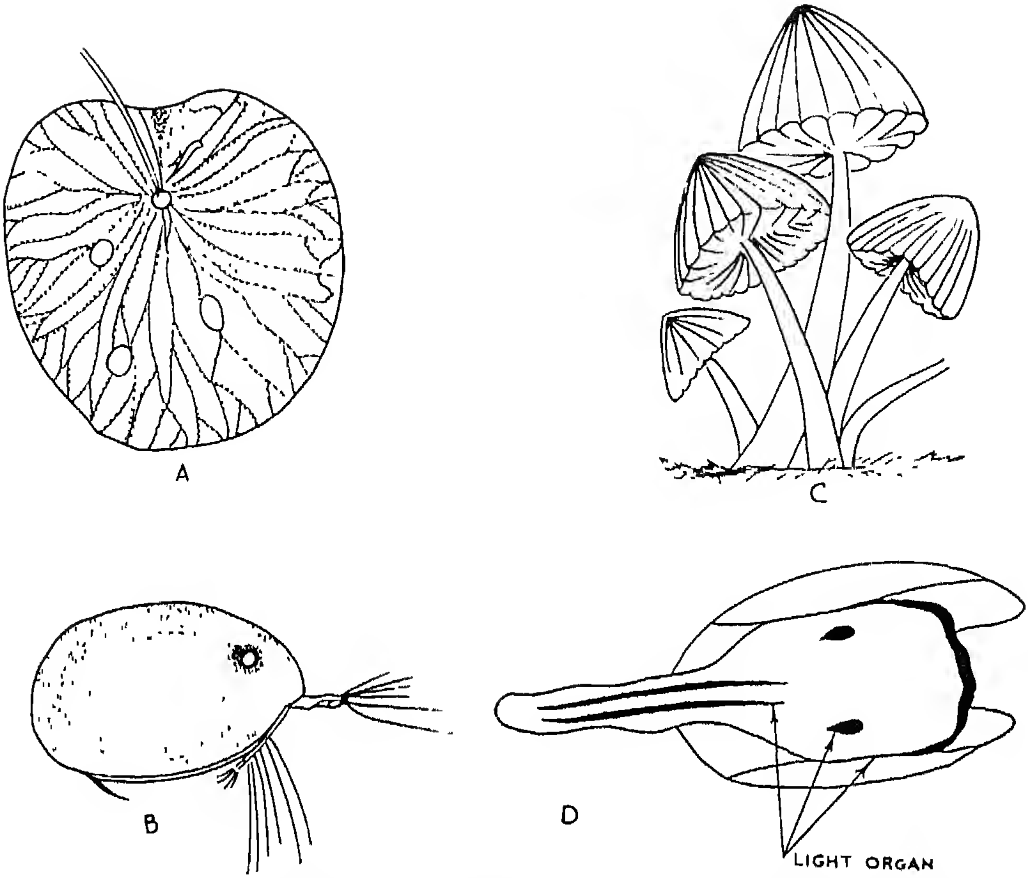

Fig. 1 *Some luminous organisms*. A. *Noctiluca*. Minute one-celled marine organism. B. *Cypridina*: A small marine crustacean. C. *Mycena*: Luminous toadstools. D. *Pholas dactylus*: An edible marine clam

like structures called 'mycelia' of fungi inside the decaying wood, abundant during damp and humid seasons.

Sometimes the dead and decaying fish, shrimps, etc., shine at night particularly in areas near the sea. The glow in such cases is due to the presence of certain luminous bacteria on the body of the dead animals. Mutton, beef and other cuts of meat kept without sufficient amount of ice or in refrigerators may become luminous for the same reason. Whenever dead fishes or their scales, flesh of animal of any kind, egg, etc., become luminous, it is certain that the light is due to the growth of luminous bacteria on them. These bacteria are of course non-poisonous to human beings. If the luminous material is of plant nature like dead vegetable matter, roots, potatoes, fruits, etc., the light is due to the presence of luminous fungi.

Apart from the above mentioned bacteria and fungi, bioluminescence is known to occur in a number of species of animals

popularly known as sponges, jelly-fishes, sea-pens, corals, comb-jellies, marine worms, earthworms, shrimps, adult and larval insects, millipedes, centipedes, snails, cuttlefishes, fishes particularly of the deep-sea, etc. But it is rather surprisingly absent among the higher plants and animals.

Structure of Light Organs

Light organs vary in structure in different organisms. In the simplest type the light may come from a single cell as in a bacterium or unicellular organisms of the group Protozoa. Again if a single unicellular organism like

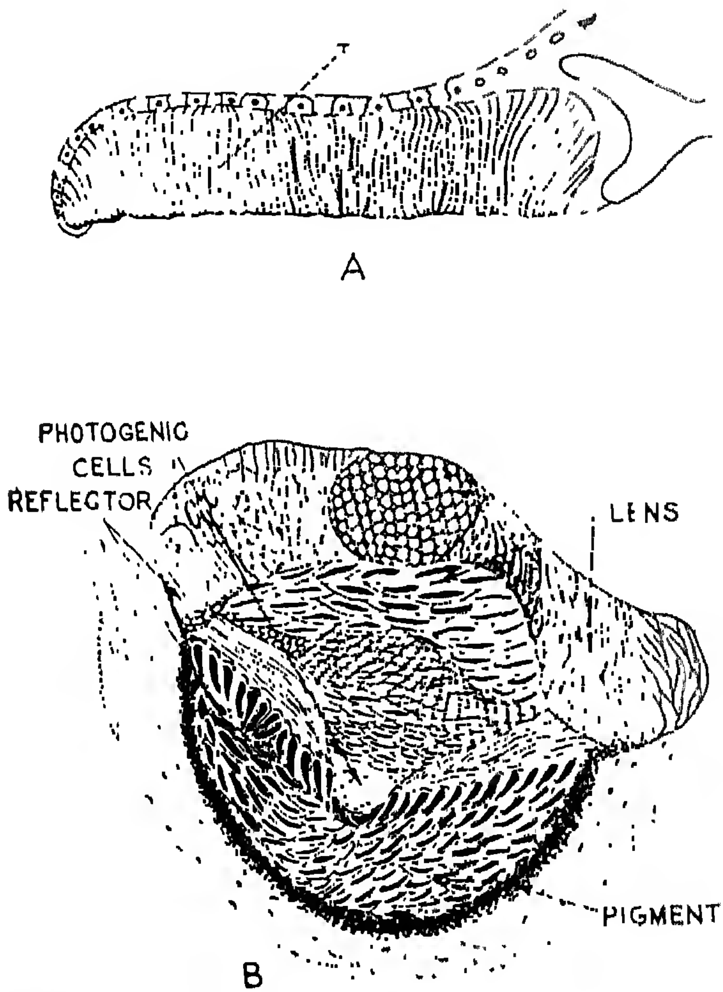

Fig. 2 A. Cross-section of the light organ of *Anamalops:* By itself this fish cannot produce light. The light is due to the presence of luminescent bacteria lodged in the tubular structures

B. Structure of the highly complicated light organ with lenses, reflectors, etc., as present in certain squids

Noctiluca is examined under a microscope, it will be seen that light is not diffused. It will be seen to come from minute points. These points are the minute granules scattered throughout the protoplasm and appear only on stimulation. In multicellular animals the light may come from either isolated patches of cells on the surface of the body or from a definite many-celled glands In these cases also, the granules within the cells are associated with luminescence. Certain complicated light organs called photophores are found in some deep-sea fishes, squids and shrimps. In these organs, accessory structures like the reflector, lens and colour screens deflecting the light are often found.

The light organs occur in different parts of the body in different organisms ; but their positions are constant and often are characteristic of the species and sometimes also of the sexes.

Mechanism of Control of Light Production

The emission of light is in two ways, viz., (i) continuous emission and (ii) intermittent emission of light of different intensities. Luminous representatives of the plant kingdom belong to the first category. They do not require any stimulus for light emission. The intensity of their steady glow depends upon the temperature, pressure changes in salt content or pH of the medium, etc. Luminous representatives of animal kingdom mostly produce light only on stimulation. Mechanical or chemical or electrical stimuli or nerve impulses can bring about the glow in animals. For example, the mechanical disturbance caused by the tossing of the waves or passage of a boat causes various marine animals to luminesce. Certain sea animals can produce light, if they are stimulated chemically by adding chemicals like ammonia to sea water. A luminous animal can also be made to luminesce when electrical current of suitable voltage is passed through it The fire-fly flashes light when an impulse passes along its nerve.

The exact mechanism of nervous control is unknown. According to one view the nerve impulse simply liberates oxygen into the light organ. The oxygen, one of the essential requirements of light production, stimulates luminescence. According to another view the process is not so simple. A series of steps triggered by the release of acetylcholine at a nerve ending in the luminous organ is responsible for light production.

Certain fishes, for example *Photoblepharon* and *Anomalops* of East Indies, emit light though they do not themselves manufacture the luminous materials in their body. They are very remarkable in that they harbour luminous bacteria in certain special glands developed under their eyes. The cells of these glands are cylindrical in shape and are richly supplied with blood. The bacteria receive the food materials from the fish and in return supply the fish with light. They do not harm the host at all. Since the light is bacterial in origin, it is emitted continuously. But *Photoblepharon* can shut off the light by drawing up a black fold of skin like an eyelid over the light organ. *Anomalops* can turn inward the light by rotating the light organ with the help of a hinge muscle at its front end. These fishes can flash their lights as they swim through the sea by these screening mechanisms. This is a remarkable instance of symbiosis, a condition in which two dissimilar organisms live together to the mutual benefit of each other.

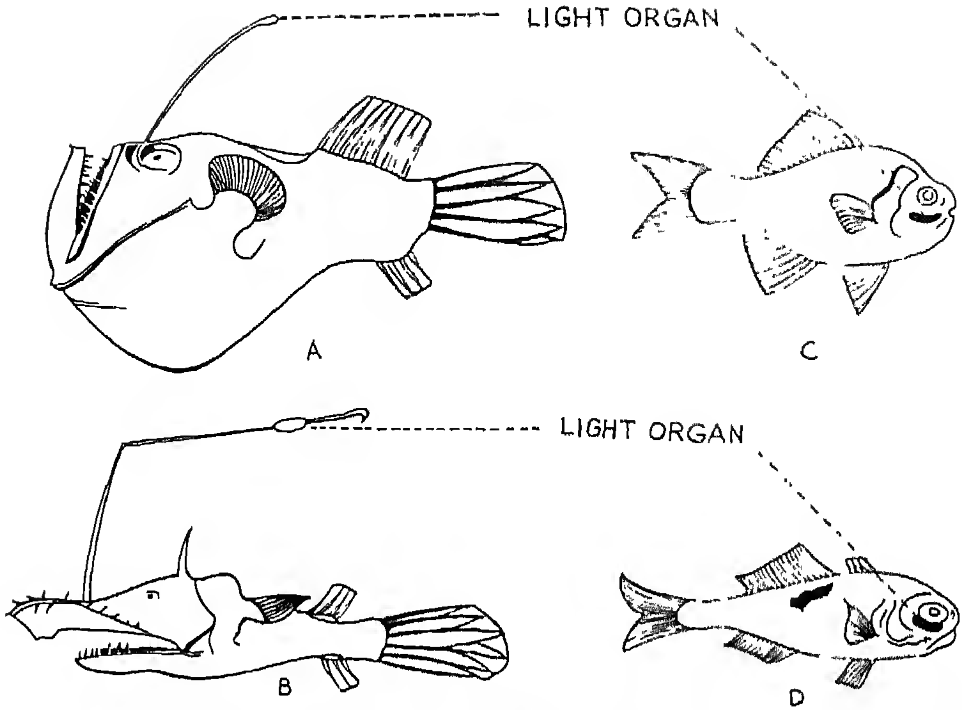

Fig. 3. A and B. The light organs help as a lure to attract the prey towards these deep-sea fishes. C. *Photoblepharon*. D. *Anomalops*. These fishes of East Indies possess the light organs due to the presence of luminescent bacteria in small tube-like structures. They can alternately turn on and turn off the light by special mechanisms

The eyes of certain animals have tapetum that reflects light like the eyes of a cat giving a luminous appearance in darkness. The so-called glow which one sees in the eyes of a cat in the dark is likely to be mistaken for bioluminescence. The tapetal layer of the eyes are capable of reflecting even very weak external light. If the eyes of such animals shine in the dark, it is a sure indication of some illumination nearby, however feeble it might be. However, if these animals are kept in a completely dark room the glow in their eyes will not be seen.

Physical Nature of Light

The light emitted by different organisms may be of any wave length in the visible spectrum. Little or no non-visible radiation is generated. The actual wave length of the emission is probably determined by the particular chemical make up of the luciferin responsible for light production. The usual colours of light are blue or green; yellow less frequent and red rather rare. In certain cases two or more kinds of luciferin may occur in a single organism, with the result that the light emitted may be of different colours. For example, the railroad worm (larval form of the beetle *Phrixothrix*) of South America is provided with eleven pairs of luminous green spots that form two parallel rows one on either side of the body. On the head of the larva there are two luminous spots producing red light. Since it gives the appearance

of a train travelling backward it is popularly called the 'railroad worm'.

In all cases the available energy is spent very efficiently. Very little heat is lost during light production. Therefore bioluminescence is often described as cold light to distinguish it from the thermal luminescence. The amount of light produced by some luminescent animals is amazing. Many fire-flies produce as much light in terms of lumens per cm^2 as modern fluorescent lamps.

Though the phenomenon of bioluminescence was known to naturalists from time immemorial, it was Dr. Raphael Dubois, a French physiologist, who first pointed out in 1887 the chemical nature of bioluminescence. He suggested that the light of the boring clam (*Pholas dactylus*) was due to a reaction involving a substance which he called luciferin. He found out that luciferin combined with oxygen in the presence of an enzyme called luciferase and the reaction produced light. Dr. E. Newton Harvey was another pioneer in the field, who contributed very much towards the understanding of this phenomenon. He showed that bioluminescence is essentially an enzymatic process. He studied the luciferin-luciferase reactions in a number of organisms among which mention may particularly be made about the fire-flies and small marine crustacean called *Cypridina*. He pointed out that the luciferin-luciferase reactions in different animals are of different types.

In recent years considerable progress has been made in this field. Scientists have succeeded in isolating the photogenic substances, viz., luciferin, luciferase, etc., in the laboratories and establishing their chemical structures. They went even to the extent of artificially synthesizing such compounds and showing that under appropriate conditions they produce light.

The chemistry of bioluminescence of at least three different organisms is well known at present They are (i) *Cypridina* (marine crustacean), (ii) fire-flies and (iii) bacteria. Light production does not necessarily depend upon life in the organism. The extracted and dried chemical compounds when mixed together usually produce light on the addition of water. The photogenic substances of these three best known luminous organisms are chemically different as shown below. They do not interact with each other, but the luciferin of one genus of fire-flies gives light with the luciferase of another genus. A short account of the luciferin-luciferase reactions of the three above mentioned organisms is given below.

CYPRIDINA: The conditions appear to be the simplest in that only luciferin, luciferase and oxygen dissolved in water are required for the reaction. Luciferin of this organism has been crystallized and its elementary composition has been given as $C_{21}H_{26-28}O_2\ 2HCl$. The detailed structure is not known yet. Luciferase has been purified but its mode of action is not known. During World War II, Japanese soldiers are said to have used dried *Cypridina* as a source of low intensity light on moistening with water, for the purposes of reading maps or messages, since flashlights would have revealed their location.

FIRE-FLY: In fire-fly also luciferin, luciferase and oxygen are found to take part in the reaction. However, in addition to the above mentioned substances, an energy supplying biological compound called in short ATP (adenosine triphosphate) and

magnesium ions are necessary for light production. The function of ATP in the presence of magnesium ions is apparently to form active fire-fly luciferin which then oxidizes in the presence of fire-fly luciferase with the emission of light.

A simplified sequence of chemical reaction that results in the production of light is given below.

Recently Dr. W. D McElroy and Dr. H. H. Seliger of Johns Hopkins University have established the chemical structure of the luciferin in the American fire-fly (*Photinus pyralis*) They also isolated and studied the light-stimulating enzyme luciferase of the fire-fly. It is found to contain about one thousand amino-acid sub-units. If this is so, it is larger than any other protein whose structure has so far been established.

BACTERIA In recent years, the study of the physiology and biochemistry of the

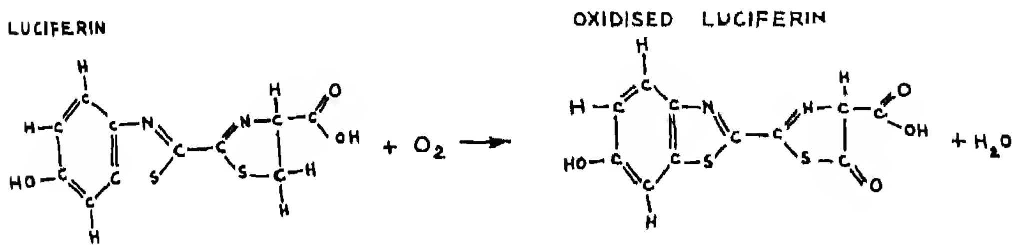

Fig. 4. The structure of luciferin in the fire-fly as established by Dr. W. D. McElroy and Dr. H. H. Seliger of Johns Hopkins University

CYPRIDINA

$$LH_2 + E + \tfrac{1}{2} O_2 \longrightarrow L + E + H_2O - LIGHT$$

FIRE-FLY

$$LH_2 + ATP \xrightarrow{Mg} LH_2 \cdot LMP + PP + H_2O$$

$$LH_2 \cdot AMP + \tfrac{1}{2} O_2 + E \longrightarrow E\,L\,AMP + H_2O$$

$$E\,L\,AMP \longrightarrow L + AMP + E + LIGHT$$

BACTERIA

$$FMNH_2\ RCHO + \tfrac{1}{2} O_2 \longrightarrow FMN + RCOOH + H_2O + LIGHT$$

$$FMN + DPNH + H^{+} \longrightarrow FMNH_2 + DPN$$

Fig. 5 The chemical reaction leading to the light production in the three well-studied organisms is shown above.
(LH_2=Luciferin; E=Luciferase, L=Oxyluciferin). ATP=Adenosine triposphhate; LH_2 LMP= Active luciferin, PP=Inorganic pyrophosphate. E.L. AMP=Enzyme product complex F_mNH_2 RCHO=Flavin mononucleotide aldehyde complex; DPNH= diphosphopyridin.

bacterial luminescence is receiving great attention The light emitting reaction in bacteria is a side reaction of the oxidative or electron transport process of the bacterial cell, which extracts energy from food. It has been found from experimental studies that the general level of the metabolic activities were not lowered, when the luminescent bacteria were converted to non-luminescent ones through artificial means.

The luciferin in bacteria is a complex of reduced flavin mononucleotide and a long chain of aldehyde. When these compounds and bacterial luciferase are brought together in contact with oxygen they produce light. The light lasts till the luciferin is used up. Since the living bacterial cell continuously emits light, the flavin mononucleotide and aldehyde must be continuously supplied. The mechanism of the continuous supply of aldehyde is not yet understood, but the supply of flavin mononucleotide is known at present. The end product of the oxidation process is acted upon by another compound, namely, reduced diphosphopyridin nucleotide and luciferin is reformed. The flavin mononucleotide thus formed is able to light in the presence of the aldehyde, bacterial luciferase and oxygen. The reaction can be represented by the reactions shown on the previous page.

Oxygen is also necessary for the continuous steady state of light. If the oxygen is not supplied constantly the intensity of light gradually falls down. This will result in the accumulation of flavin mononucleotide which produces suddenly a brilliant flash of light on readmitting oxygen. All these reactions can be artificially demonstrated in the laboratory with aldehyde DPNH and a cell-free extract of bacteria.

Uses of Bioluminescence to the Organisms

In fire-flies the luminescence is used as signals to attract the sexes to one another. Each species has a special kind of signal which is characterized by the length of the flashes and the interval between them.

In deep sea animals living in perpetual darkness the light organs serve to illuminate the surroundings to facilitate the search for food. The pattern of distribution of these light organs on the body of deep sea fishes is often characteristic of the species and show certain variations between sexes. This perhaps aids in the recognition of the members of the same species or members of the different sexes of the same species.

It is well known that squids discharge black ink, when attacked by enemies and escape. Since the black ink might not serve the above purpose in complete darkness of the deep seas, the deep sea squid (*Heterotheuthis dispar*) has the capacity to manufacture luminous secretion.

The light may act as a lure to catch food as in deep sea angler fish which has a lantern at the tip of its tentacle. The sudden turning on and off of a bright light is an adaptation for some animals to scare away their enemies.

However, some deep sea animals possessing light organs are completely blind due to the degeneration of their eyes. We do not know what useful purpose the bioluminescence serves in such organisms. It is again rather surprising that no luminous animal has been found in such large bodies of freshwater lakes like the Lake Baikal in Siberia where total darkness prevails as in deep sea.

Many luminous marine forms live in the region of the sea, where light penetrates. In these the animals may luminesce at night in order to lure prey or to elude natural enemies.

The light emission in advanced animals is an adaptation to some functions such as mating signal, lure for prey, protective screen, etc. But what function it serves in organisms like bacteria, fungi, protozoa, etc., is not immediately known. The light emitted by bacteria and fungi probably serve no useful purpose to the organism, but is simply a by-product of oxidative metabolism just as heat is a by-product of metabolism of plants and animals.

Origin and Evolution of Bioluminescence

Bioluminescence is scattered in a haphazard fashion throughout the animal kingdom. There is no indication that light-production arose at a particular time or in a particular group and that it followed definite evolutionary pathways.

There are two views put forward to account for the origin and evolution of bioluminescence among the organisms. According to one view bioluminescence arose in an organism as a luminous spot due to chemical mutation. Once such a spot appeared on an animal or plant, the light might have been of value and may have persisted by natural selection. The reverse process is also possible. It has been found that sometimes the luminous bacteria may become non-luminous and this is due to the loss of the capacity of the organism to produce certain substances. It has been possible to induce such mutations by radiation techniques. The strains of such bacteria lose their capacity to produce light. But if certain chemical substances like aldehyde are added to the cultures they emit light.

The other view is recently proposed by Dr. W. D. McElroy and Dr. H. H. Seliger of Johns Hopkins University (U.S.A.). According to this view, 'bioluminescence was originally an incidental concomitant of the chemical reactions that were most efficient in removing oxygen from living systems.' It is now a widely acknowledged hypothesis that the earliest organisms on earth must have been anaerobic forms, viz., organisms that could exist on earth without oxygen and depended for their energy on the process of fermentation. But in the course of time oxygen began to accumulate as a result of the solar decomposition of water vapour. Added to this, certain primitive organisms might also have released oxygen as a by-product of their simple photosynthesis. The presence of oxygen might have proved toxic to the early anaerobes. It is quite possible that the oxygen was eliminated as water by reduction and the reducing substances were the organic compounds that were part of the hydrogen transport system of the primitive anaerobes. Therefore, the organic compounds must have been excited to emit light with the help of the energy that might have been released in the process of conversion of oxygen to water. It is not to be assumed that all early organisms could easily get rid of oxygen in the manner described above. Only certain of the organisms could have succeeded in this direction and they were all potentially luminescent forms.

It is also probable that the amount of oxygen present in the primitive organisms was extremely low. Experimental results

with bacteria show that bioluminescence could be produced with the use of oxygen in extremely low concentrations During the further course of evolution, anaerobes could utilize oxygen in their metabolic process, without resorting to eliminate them as a toxic material. Therefore, the light reaction associated with the process of removal of oxygen was not of any selective value. But since it evolved with the primitive electron transport process, it could not be easily got rid off. The experimental evidence obtained from luminescent bacteria again shows that the light reaction is a side branch of the oxidation-reduction reactions that extracts energy from food and the enzymes taking part in the reactions are not at all necessary for the proper metabolism of the organisms. For example, when the light production is suppressed by certain techniques in a culture of bacteria, the growth of them was not affected in any way. The non-luminous strains of bacteria obtained from the strains of luminous bacteria, by radiation techniques, showed normal growth and reproduction Thus bioluminescence is considered as a 'vestigial system in organic evolution' and is supposed to be preserved in the various and unrelated speceis of organisms of the present day through the secondary process of adaptation.

Scientific ideas rarely drop out of the blue skies. They grow and mature through the years, often through the centuries. They hang in the air until somebody able to grasp their importance picks them up and gives them shape and meaning for us all.

L. J. Ludovici in *The Chain of Life*

Fauna of Our Oceans—Littoral Life

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THE word 'ocean' is derived from the name 'oceanus' which the Greeks had given to a river that flowed, according to them, around the earth considered by them to be flat. However, as our knowledge about the earth and the oceans surrounding it increased, the wheel maps of the olden days were replaced by the most modern ones which now tell us that there are three great oceans in this world, viz., the Atlantic, the Pacific and the Indian. The last one is named as such because it washes our shores which extend over nearly 4700 kilometres

Regarding the origin of these oceans, it may be stated that in the beginning, even the earth was just a part of the sun. It was, therefore, as hot as the sun itself when it separated from it. Gradually, however, it cooled down with the result that its outer surface became rocky, but the inner portion still remained at a very high temperature on account of the hot gases which originally constituted it These occasionally caused the eruptions of some of the rocks at their tips with the result that huge craters were formed and the hot lava flowed down the rocks. As a consequence of the high temperatures prevailing on the surface of the earth, it remained surrounded by clouds formed due to the condensation of the atmospheric vapour. Gradually, however, these clouds rained and the water, this collected in the huge craters and the valleys in between the rocks, formed the oceans.

Those who have been to any coast know that the sea water rises and falls at regular intervals. Such a rise and fall in the level of sea water constitute what we call the high and the low tides respectively. These are caused by the force of attraction which both the moon and the sun exert on our waters. The impact of the rising tides on the rocks is so great that they are broken completely with the result that we have sometime a shore which, instead of being rocky, is just in the form of a sandy beach. Besides these two types of shores, i.e., rocky and sandy, there is still another type which is muddy. Such a shore is found either at the mouths of the rivers or in some sheltered creeks.

The strip of land which lies between the high- and low-water marks and which becomes uncovered twice daily when the tide is at its lowest ebb is known as the littoral zone of the sea shore. The conditions in the zone are so variable that the animals living comfortably in the cool waters of the high tide may be found stranded at the time of the low tide in a rock pool in which the temperature of water on account of the hot sun may even rise to such an extent as to cause the death of all the organisms living therein. Even the nature of the sea water itself is bound to change especially near the mouths of the rivers on account of its mixing up with the fresh water. On the other hand, the sea water in certain enclosed areas may become even more salty on account of its greater evaporation during summer.

In order, therefore, to successfully adapt themselves to such varying conditions, the animals living in the littoral zone have to be very tough and hardy. In spite of all these handicaps the fauna of the sea shore is so varied and dense that we have not got its parallel anywhere else. There is a continuous struggle going on between the inhabitants of the sea shore not only for their own existence but also for their food and reproduction. In this struggle only those animals which are strong and well protected survive and the others die. Their death can, however, be avoided only if they succeed in hiding themselves from their enemies.

We shall now describe some of those animals which live on our rocky shores. First of all we come across the sessile barnacles like *Balanus* firmly attached to the rocks in the form of small pyramids. They constitute a definite *Balanus* zone near the high-water mark. The common limpet, *Patella* may also be seen browsing on the sea weeds found in this area. Then there are the *Chitons* with their shells divided into eight pieces. Near the low-water mark the rocks are found covered over with a carpet of sponges of the various colours, colonial sea squirts like *Botryllus* and sea mats like *Membranipora*. We may also get here the various types of bivalves like the oysters, *Mytilus* and *Pecten* etc. Whereas the oyster is permanently attached to the rocks by means of its shell, *Mytilus* and *Pecten* make use of their tough fibres constituting the 'byssus' to secure themselves.

Some other animals become exposed as soon as we start turning over the loose stones lying on the sea shore

Just near the high-water mark, we get a number of small crustaceans like *Gammarus* and insects like beetles. As we go down the sea shore, we get *Lineus* and some other nemertines. These worms are sometimes so long that it becomes impossible to take out a complete specimen without breaking them. We may also come across small techni-coloured flatworms, moving slowly on the surface of the stones. Then there are the various types of bristle worms and as we reach the low-water mark, we also get specimens of *Nereis* which are generally used as a bait. There is another common worm *Polynoe* which is not only broad but also flattened. It is also provided with two rows of very large scales on its dorsal side, enclosing a space between them and the body wall which serves as a respiratory chamber. From amongst the crustaceans, the crabs are so common that you will get one variety or the other whenever you turn over any stone. The most characteristic of these is the hermit-crab which lives inside the empty shell of a gastropod and on that may occasionally be found attached either a small sea anemone or a sponge. Such an association of animals belonging to widely different groups is known as commensalism. In this type of association the sea anemone or the sponge provides protection to the hermit-crab and in return gets food by going from one place to the other riding on the swift moving hermit-crab. Starfishes and sea-urchins are also quite common near the low-water mark. Where the former have five arms radiating from the central disc, the latter are globular and covered over with long and thick spines. Another unique feature of both of these echinoderms is the possession of a water vascular system which is so useful in locomotion. Some of the small fishes are also found hiding

underneath the stones on the sea shore. Once, while looking for animals on the rocky shore near Dwaraka, we could collect even an eel in a similar situation. But it was really in a very ferocious mood when we located it underneath a stone and we had to do quite a good bit of manoeuvring before we could get at it.

Then in the holes and creeks of rocks are also available the various kinds of worms, crustaceans and echinoderms like the Holothurians. Some of the rock burrowing molluscs like *Lithophaga* strayoctopus which may be lurking here and there in search of fish or crustaceans on which it may dart without giving them any notice whatever. Another interesting feature about octopus is it can evade its enemies by making the water turbid with the ink which it gives out from its ink-sac while fleeing swiftly.

The most fascinating spot on the sea shore for a zoologist is, however, a typical rock pool. The various types of sponges, hydroids, sea-mats and sea-squirts cover its sides. But among them the sea-anemones become all the more prominent because they just look like flowers with their rich and beautiful colours. Then there are the sea-slugs with their backs covered over with soft and grey projections, the sea-lemon, *Doris* and the prawns of various kinds.

In contrast to a rocky shore, the sandy shore has an entirely different type of fauna. On such a shore all the encrusting animals are quite conspicuous by their absence because they do not find here any hard structures to attach themselves. As most of the animals on a sandy shore have to spend a good deal of their time under sand, they are very efficient in burrowing. For example *Cardium* can not only move about but also burrows by means of its wedge-shaped foot which it can protrude through the opening in between the two halves of its shell. In some of the burrowing molluscs, the shell is reduced so that they may have a better grip on sand. The razor-fish, *Solen* may also be dug out occasionally at the time of low tide. The two halves of the shell in this mollusc form a cylinder which is open at both ends. Whereas the lower opening is for the protrusion of the foot, the siphons come out of the upper one. Besides the molluscs, there are a number of worms found buried in the sand with only their tentacles exposed. Of these, the Terebellids can be easily made out on account of their sandy tubes. *Amphitrite* is another important member of the fauna available on the sandy shore and so is *Arenicola* which can be easily recognized by its peculiar castings just like those of the earthworm on land. Quite near these castings one can also notice a small depression at the base of which is situated the head of the animal, its burrow being U-shaped. Another animal found on a sandy shore and which may be easily mistaken for a worm is *Synapta*. This is, however, an echinoderm and is related to the sea-cucumbers. Similarly, the cake-urchin, *Clypeaster* may also be occasionally dug out of the sand.

We also get here a number of crustaceans like the shrimps which can often be missed on account of their sandy colour. Besides them we have the various types of sea anemones which lie buried in sand with only their mouths and tentacles exposed. Some of the fishes can also be encountered in the shallow waters of the sandy shores. Occasionally they may be stranded in small pools on the sea beach. Similarly, some of the jelly-fishes and Siphonophores like

Physalia or the Portuguese Man-of-War and some sea-snakes are also left stranded on our sandy shores

On a muddy shore also the burrowing forms are as abundant as they are on a sandy shore. They may be bivalved molluscs or worms of the various types especially those found in the tubes. Of these, *Sabella* is provided with a rubber-like tube which, on the other hand, is quite thick and gelatinous in *Myxicola*. Then there are several varieties of sea anemones and crabs. Some of the air breathing fishes like *Periophthalmus* and *Boleophthalmus* may also be encountered on our muddy shores. It is, however, very risky to collect these animals because one may often sink knee deep while hunting after them in mud. Another group of animals which is equally well represented on a muddy as well as a sandy shore is that of Gephyreans. They include the Echiurids and Sipunculids. The Echiurids have a ribbon-like proboscis which is richly ciliated and glandular. The cilia help this animal in bringing towards its mouth minute microscopic organisms which are then glued together by the secretions of the glands. The forms which are commonly met with in our littoral zone belong to the genera *Ikedosoma*, *Ochetostoma* and *Anelassorhynchus*.

The Sipunculids are characterized by the possession of a peculiar organ called the 'introvert' which can be withdrawn when not in use. Another feature of this animal is the shifting of the anus towards the anterior end with the result that the antero-posterior axis is shortened.

This brief survey of the animals in our littoral zone will not be complete if I do not make any mention of the coral reefs and islands. They are formed mainly by the stony or Madreporarian corals which are also coelenterates just like the sea anemones. The only difference is that they secrete around and underneath themselves a thick skeleton of calcium carbonate The corals may be solitary but most of them are colonial, each colony comprising a large number of individuals, their skeletons being fused together to form a very big stony structure. The corals which are generally displayed in our museums are only these skeletal remains which during life are covered over by the living tissues of the animal with the feeding polyps opening and closing rhythmically. There are also a number of corals which are just hydroids differing from them only in having a thick and calcareous skeleton. *Millepora* which is one such coral possesses two types of polyps—one devoid of a mouth but with batteries of stinging cells used for capturing the prey and the other with mouth for swallowing and digesting it. *Tubipora* or the organpipe coral is another important constituent of the coral reefs. It is, however, a false or Alcyonarian coral in which the skeleton is in the form of a large number of small tubes running parallel to one another. They are deep red in colour and are united by horizontal platforms. During life the green tentacles of the polyps can be seen projecting out from the free ends of these tubes. Only the upper portion of this coral is provided with living tissues, the lower being abandoned with the gradual growth of the colony. The latter, therefore, becomes a wonderful abode for a large variety of animals. The Bonellids, for example, with a bifid proboscis are usually found in some of these coral rocks. The males of Bonellids are minute worm-like creatures showing no resemblance whatever to the female

which, however, is quite big. The former lives like a parasite inside the nephridia or the uterus of the latter drawing its full nourishment from the host. The sex in this case is supposed to be determined by the environment, because the embryo grows into a female if it is allowed to develop independently. But if during development it comes in contact with a female, it grows into a male.

It will, thus, be seen that in the littoral zone of the sea shore one can find a great variety of animals, ranging from the minute unicellular protozoa right up to the most highly evolved mammals like the dolphins and porpoises which are sometimes left stranded there. Similarly the penguins, seals and walruses visit the coasts during their breeding season. Even the sea turtles are known to lay their eggs in sand on the sea shore.

Development of Science Fairs in the U.S.A. How and Why the NSF-I Developed

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INTRODUCTION

THE National Science Fair-International* was started in 1950 in the U.S.A as an attempt to serve a number of different purposes that concerned students, teachers, the news media, the scientific community, and the public in general. These will be discussed separately.

STUDENTS: The need for scientists in our country was intensified by the rapid developments during and after World War II. For the needed manpower we sought a way to increase student interest in science careers. If a way could be found to base judgement of aptitude in science on more than just marks—or grades—it was felt that a better assessment of their aptitude for science could be made and opportunities made for those so detected. We felt this must be put on an optional rather than a required basis to place a premium on motivation for the hard work that all science disciplines require.

TEACHERS: At that time many of our science teachers were poorly paid, overworked, and insufficiently trained for the fast-moving science our students should be learning. Better science teachers had been drained away in many cases by higher salaries in industry and government and a high percentage of those remaining were well-versed in pedagogy, but weak in science subject matter. There was a great need to align teaching with new concepts in science to prepare our students for ready acceptance into the world of the scientists without need for later retraining. It appeared possible to bring this about by a closer alliance between teachers and scientists through the students with mutual benefit to all.

THE NEW MEDIA: Science news in newspapers, magazines, radio, television was becoming increasingly important but there was need to personalize the facts to make them more palatable to listener-reader-viewer. A steady flow of human interest-type stories combining hard scientific information with the warmth of human involvement would increase the demand for science news and the understanding of it. If this supply of news could be centered in youth it would be further enhanced as stories about young people are especially desirable in our culture. Therefore, news of young people doing up-to-date science would combine two important aspects of news-worthiness.

THE SCIENTIFIC COMMUNITY: All levels and all branches of science were in constant

* Hereafter referred to as NSF-I

need of new, well-trained personnel. Especially sought by industry, government and the academic were young people with fresh ideas, aptitude proven to be beyond the average, sound theoretical information tempered with knowledge of practical applications of theory and, most of all, willingness to tackle difficult problems with hard work learned through well-established habits of self-discipline Some way to spot such young people early enough in their academic training would make it possible to provide them with opportunities to develop their unusual qualities without delay and in line with their particular aptitudes and career desires.

The Public in General: A way needed to be found to increase the science literacy of our voting public to enable them to cope with problems they face as citizens in a country moving rapidly ahead in a world of science. This might be done by bringing science into their homes by encouraging their children to work in it—not merely study it. Public viewings of student work in science could be made a means of explaining science through the displays of projects done by children. Explanations at this level would be more entertaining than lectures by adults. Job opportunities for young people needed to be understood by the parents so that they could help guide their sons and daughters wisely into the fields where they were most able to function at their maximum potential without fear of failure and financial loss from misplaced education.

The NSF-I as originally planned and improved over a 15-year period has served to amalgamate these diverse elements in an amazing fashion and has opened new avenues of endeavour not dreamed of in 1950.

The NSF-I in 1964

In 1964, during the three days the NSF-I was open to the public, 100,000 people passed through the miles of exhibits to view the work of the best the country could produce in student-science for that year Such crowds—or even larger—have been common at every NSF-I as this showcase of science had been taken to a different city annually to give people in all parts of the country a chance to see what is happening among secondary school-age students headed for science careers.

The decision to move the fair to a new city each year has provided an education to the adults who attend year after year to bring their current finalists. In no other way could they have had so rich an education in how science operates in the U.S.A. than to have had five days in each of the 15 cities with every minute planned to increase their knowledge of the science unique to that city.

Building science projects for science fairs has become such a common thing in the U.S.A. that the spring of the year is often referred to as 'science-fair-fever time'. In 1964 it is estimated that at least 1,500,000 exhibits were designed and constructed for science fairs throughout the country. Besides the obvious benefits from this whole-sale intellectual competing, the intermingling of information that results from students meeting students, teachers meeting teachers, parents meeting parents, from many widely spaced areas has brought about a cross-fertilization of thinking that has enriched youth and adults in broadening their knowledge of science.

Many of the science fairs are financially sponsored by our newspapers and they

carry news of the boys' and girls' work from the simplest fairs through to the big finals at the time of the NSF–I. The amount of science news they must carry to satisfy the craving for the 'latest' by their young readers extends the need to carry extensive science news throughout the 12 months. This is reflected too in magazines, radio, television coverage of the latest things in science.

Parent, educator and scientist recognition of weaknesses in local schools, when their children's work was compared to that of other communities and states, is partly responsible for the wave of improvement that has swept our country in the last decade to up-date textbooks, retrain teachers, improve libraries and laboratories and in other ways, improve preparation of students for their future in science.

Scientists, colleges, universities, job placement authorities are only a few of those who now rely heavily on the records made by our students in this form of extra-curricular effort in science. High standing in science fairs is an indicator of dedication to effort that sways acceptance in jobs, undergraduate enrolment and careers.

That the NSF–I programme has lasting appeal for the students is evidenced by the fact that the number competing at the NSF–I has had a steady rise from 30 in 1950 to 420 in 1964. The popularity at the local level has been so great that in many cases the eliminations have had to be increased in order to accommodate those appearing for the final regional or state fairs. Even with these eliminations some of these fairs now have as many as 5,000 exhibits on the floor at one time.

It is hard to guess which had profited most from the science fair programme: students, teachers, scientist community, the news media, the public in general. There can be no doubt that the idea is suitable for our culture and gives no hint of dying out now or for any time in the future.

The NSF–I in Baltimore

During May 5–9 1964, Baltimore, Maryland, entertained the Fifteenth Annual NSF-I. This exciting, intellectual gathering for boys and girls, who plan to be scientists, was visiting this city for the first time. Baltimore had spent three years getting ready to show off the science of city (as had 14 other U.S.A. cities in the previous years) and arrange trips and excursions to points of scientific interest as far away as Washington D.C., Annapolis, Maryland and Gettysburg, Pennsylvania.

The 'stars' of this big show of science were 420 secondary school students from the 10th, 11th and 12th year of high schools in all parts of the U.S.A. and from many foreign countries. They had survived from one to five judgings by teams of scientists. They had started in their local school science fair and moved on to compete in subsequently larger inter-school and country-wide fairs, until they were fortunate to be chosen to represent one of the 222 regional or state fairs serving most of the country through a system of carefully laid out territories in which students could compete in the fairs with a minimum of travel on their part.

The 420 students were 15 to 18 years of age and brought with them to Baltimore the projects they had designed and built

to illustrate the extent of their extracurricular work in Science over a period of months or even years. Most of them were 'old hands' at science fairs since they had participated from the beginning of their schooling (some as early as kindergarten or primary school) and were in the habit of winning. Some had even been to the NSF-I before as contestants in other cities (a student may be named three times to be a finalist). But none of them had ever faced so formidable a competition as this one. The quality of the NSF-I escalates as the competition raise the judging more stringent by each passing year. Over 350 eminent judges, representing every facet of science and technology, were assembled from great distances as well as in and near Baltimore to pass judgement on the finalists. Each one of them was privileged to talk to and received guidance from at least five of the judges.

The 420 finalists were accompanied by adults : science teachers, science fair directors, news reporters and news photographers. Each of the 222 affiliated fairs had sent with their contestants an adult party of four to ten persons to enjoy the minute-by-minute programme and learn with the students what lay ahead in the future of science. The adults were sent on the all-expenses-paid trip to perform certain functions and gain additional training too. Each was charged with the duty—as were the finalists—to impart their new knowledge to those left 'at home' waiting to hear their newspapers, radio, television or in-through persons' reports of the pleasures and learning absorbed at the NSF-I.

Science teachers met science teachers to learn new ways of teaching and inspiring young scientists.

Science Fair Directors met others having similar duties to exchange ideas on how to improve the mechanics of small fairs leading to their regional or state ones over which they had jurisdiction.

News reporters and photographers reported every event of the thrill-packed trips, expeditions, lectures, visits to research laboratories, entertainments, banquets, and so on, to those at home so that they could follow each step of the busy five days as experienced by the 15-18 year-olds that represented them at this international function.

The NSF-I Awards

The awards at the NSF-I are of two kinds and there is no limitation on how many a finalist may receive.

One set of awards is a dividing of funds contributed as entry fees for affiliating with the NSF-I. This fee is paid by the local group holding the regional or state fair and may be collected from many local sources or contributed by one agency, such as a newspaper, university, civic group, etc. This fee entitles the fair to send not more than two finalists to the NSF-I.

The NSF-I Awards are set up to serve all fields of science with 1st (\$100), 2nd (\$75), 3rd (\$50), 4th (\$25) awards (the number totalled 297 awards in 1964). Each finalist, as soon as chosen to represent an affiliated science fair, fills in a 'Wish List' of exactly what is desired, if any of these awards is won. They may 'wish' for any kind of scientific apparatus, equipment, publications or such that will further their work in science, but no money is given outright. As soon as the NSF-I

Awards are made the 'wishes' are granted and the materials requested are secured and sent to the award winners.

Listed below are the 1st and 2nd NSF-I Awards for 1964 showing the age of the finalist, title of the project and the category in which the award was made. The name of the State or country of the winner is given in parenthesis.

BOTANY

FIRST

17* Research on the Pollen of *Lilium longifolium*. (Japan)

16 Antibiosis Study of Fresh-water and Marine Algae. (Indiana)

SECOND

16* Evaluation of CO_2 and O_2 Production by Aquatic Plants in a Closed Ecological System under Controlled Illumination. (North Dakota)

17 Answers to the 'Papaya Repllant Problem'. (Hawaii)

CHEMISTRY AND BIO-CHEMISTRY

FIRST

16* Spectropolarimetric Analysis of the Secondary Structure. (New York)

18 Control of Anthocyanin Synthesis by the Photoreceptor System. (Georgia)

SECOND

16* Immunoelectrophoresis. (Pennsylvania)

15 Isotropic and Anisotropic Polymers. (Illinois)

EARTH AND SPACE SCIENCES

FIRST

16* Jupiter—Composition, Structure, Origin. (Virginia)

18 Atmospheric Refraction of the Low Sun. (West Virginia)

SECOND

18* An Analytical Study of a Martian Phenomenon. (Florida)

17 The Making of a Ramjet. (California)

MEDICINE AND HEALTH

FIRST

17* Mutagenic Effects of Ultraviolet Radiation on a Strain of *Bacillus subtilis*. (Minnesota)

17 Determination of Suppressor Gene Loci in *E.coli* K-12. (Texas)

SECOND

17 Possible Site of Action of Hormones in *Tetrahymena pyriformis*. (Rhode Island)

18 Behavioral Tests of Offspring from the 25th Generation of X-Irradiated Mice. (New Jersey)

16 Production and Testing of Avian Pronchitis Vaccine. (Iowa)

PHYSICS

FIRST

16 Nuclear Quadrupole Resonance Effects. (California)

16 A New Nuclear Magnetic Interaction. (Massachusetts)

SECOND

18 Stoichiometric Doping of Intermetallic Thermo Elements. (Arizona)

17 Design of Autogyros. (Texas)

MATHEMATICS AND COMPUTORS

FIRST

17 Analysis of the Total Number of Twists Resulting from Cutting of Any Order Moebius Band with Any Number of Cuts. (Kansas)

SECOND

17 ESP—Fact or Fiction. (Connecticut)

ZOOLOGY

FIRST

17* Germ-free Chicken Experimentation. (Kentucky)

18 Stimulus Induced Changes in the Synaptic Complex. (Kansas)

SECOND

17 The Voice of the Coqui. (Puerto Rico)

16 Inducing Pregnancy by Artificial Insemination in C-57 Mice. (Pennsylvania)

The Professional Awards

The second set of awards at the NSF-I is given by various professional organizations and governmental agencies for projects done by students within the range of the interests of those organizations and agencies. Each provides its own judges to look for the specific types of work in which they are anxious to find competent young people

The awards given are varied and show the opportunities offered to promote the training of those chosen—and often for their science teachers also.

The list below gives the top winners only with their ages, titles of their projects and home state.

The American Chemical Society

To each of two finalists a plaque and $100 for science materials and study. Plaques for two alternates. Subscriptions to *Journal of Chemical Education* for all four. Special plaques to one teacher of each.

17* Detection, Identification and Isolation of Natural Pteridines and Their Effects on Embryonic Development. (Louisiana)

17 Isolation of Sodium Superoxides from Sodium Ozonide. (Massachusetts)

The American Institute of Biological Sciences

Expense-paid trips to the annual AIBS conventions for two finalists.

16 Effects of Gamma Irradiations' Induced Mutations on Snapdragons. (Pennsylvania)

18 Stimulus Induced Changes in the Synaptic Complex. (Kansas)

The American Institute of Mining, Metallurgical and Petroleum Engineers

Certificate to first and alternate finalist. $100 (to first) $75 (to alternate) U.S. Savings Bonds. Subscriptions to one of AIME journals to each.

17 Tin—The Metal That Cries. (New York)

The American Psychological Association

Certificate of Merit to first and alternate finalists. $100 U.S. Savings Bonds to first.

15 Does Mother-Fetor During Infancy Affect Growth and Behaviour in Maturity ? (Georgia)

The American Society for Microbiology

Plaque, Certificate of Merit, $100 to first to further career.

Plaque, Certificate of Merit, $75 to second to further career.

Honorable Mention plaques to three alternates.

16 Production and Testing of Avian Bronchitis Vaccine. (Iowa)

The Entomological Society of America

$100 U.S. Savings Bonds and current issue of *Annual Review of Entomology*.

17 Fractionation of *Drosophila melanogaster* and Correction of Hereditary Diseases. (Maryland)

The National Aeronautics and Space Administration

Certificates of Merit and two-day visits to NASA facilities to each of 12 finalists in six categories. Each of 12 to name one teacher to accompany him or her on the visit. Expenses-paid for all.

IN AERODYNAMICS AND SPACE FLIGHT

17 Design of Autogyros. (Texas)

15 Effects of Rocket Flight on Training. (Michigan)

IN SPACE VEHICLES

18 Micrometeoroid Erosion and Spacecraft Materials. (Oklahoma)

15* Mouse in a Closed Ecological Environment. (Washington)

IN SPACE PROPULSION SYSTEMS

17 Acceleration of Charged Particles for Space Propulsion. (Mississippi)

17 The Making of a Ramjet. (California)

IN SPACE LIFE SCIENCES

18* An Analytical Study of a Martian Phenomenon. (Florida)

17* Sleep—A Habit ? Rest—Necessary ! (New Mexico)

IN SPACE PHYSICAL SCIENCES

17 General Mathematical Model of a Zwicky Humason Star. (Virginia)

16* Jupiter—Composition, Structure, Origin (Virginia)

IN SPACE ELECTRONICS AND COMMUNICATIONS

16 Experiments in Simplification of Television Image-Conversion and Transmission. (New Jersey)

16 Simultaneous Oscillations in Negative Resistance Devices (Texas)

The National Committee for Careers in Medical Technology

A certificate, a summer (vacation) job at the American Registry Pathology at the Armed Forces Institute of Pathology in Washington D C. and $100 travel expenses for the journey. One alternate; two honorable mention citations.

17 Thalidomide Induced Teratogenic Differentiation in Chick Embryos. (North Carolina)

The National Pest Control Association

Certificate and $100 for science materials and experimentation in biology.

17 The Fascinating World of the Ant. (Kentucky)

The National Telemetering Conference

Certificate and trip to annual conference of NTC to show project there. Choice of teacher to accompany on trip. One alternate

17 Multi-Channel Optical Communications. (Florida)

The Optical Society of America

$100 (for first $75 (for second) for materials, equipment or books.

17 Determining the Velocity of Light. (Colorado)

The Society of Women Engineers

$100 U S. Savings Bond

17* Quantization of Direction in a Magnetic Field; the Stern-Gerlach Experiment. (New Mexico)

The U.S. Atomic Energy Commission

Certificates and trips to Argonne National Laboratory for 10 finalists and choice of one teacher each for all-expenses-paid trips. 10 alternates received certificates.

17* Bacterial Protection Against Radiations. (Maryland)

17* Bio-chemistry of Cholesterol in the Biosynthesis of Ergosterol in *Neurospora*. (California)

16* The Universe of Subatomic Structure. (Louisiana)

17 Germ-Free Chicken Experimentation. (Kentucky)

16 A new Nuclear Magnetic Interaction. (Massachusetts)

17 Effects of RNA and DNA Nucleotides on Growth, Morphology and Biochemistry of Irradiated *E. coli*. (New York)

17* Atomic Transmutation. (Michigan)

15* Spark Chamber Construction and Operation. (Texas)

17* Effects of Radiation on Electrocardiographic Development of the Chick Embryo Heart. (Oklahoma)

18 Effects of Serotonin Against Gamma Radiation. (Michigan)

THE U. S. PATENT OFFICE AWARDS

(sponsored by the Patent Office Society)

Certificates and $50 to one in each category.

IN MECHANICAL ENGINEERING

17* The making of a Ramjet. (California)

IN ELECTRICAL ENGINEERING

16 Experiments in the Simplification of Television Image-Conversion and Transmission. (New Jersey)

IN CHEMICAL ENGINEERING

17 Isolation of Sodium Superoxide from Sodium Ozonide. (Massachusetts)

FOR DESIGN OR DRAMATIC VALUE

17 Clowning Around with Algebra. (Tennessee)

The U.S. Army

A certificate and either a trip to an Army Research facility or the opportunity to accept a salaried summer job as a student trainee in a research laboratory of the Army for each of 19 finalists. Meritorious second award to 17 finalists.

17 Plasma Physics (West Virginia)

16 Simultaneous Oscillation in Negative Resistance-Devices. (Texas)

17 X-Ray Power Supplies (Florida)

16 A New Nuclear Magnetic Interaction. (Massachusetts)

15 Learning Ability of Four Rodents (Arkansas)

16 Inducing Pregnancy by Artificial Insemination in C-57 Mice (Pennsylvania)

18 Atmospheric Refraction of the Low Sun. (West Virginia)

17 Phenomena of the Fluvial Geomorphic Cycle. (Oklahoma)

17 Analysis of the Total Number of Twists Resulting from Cutting any Order Meobius Band with any number of Cuts. (Kansas)

18 Fluid Computer System. (Alabama).

16 A Machine which Duplicates the Learning Process. (Texas)

17* Influence of the Borate Ion on Crystals of Sodium Chlorate and Sodium Borate

Orientated in an Electric Field. (Kansas)

16* Spectropolarimetric Analysis of the Secondary Structure of Gramicidin-S and Tyrocidine-A. (New York).

18 Control of Anthocyanin Synthesis by the Photoreceptor System. (Georgia)

17* Effects of RNA and DNA Nucleotides on Growth Morphology and Biochemistry of Irradiated *E.coli*. (New York)

18 Hibernation *vs* Hypothermia. (Arizona)

17* Electrical Conductivity in Malignant and Non-Malignant Tissues. (Indiana)

17* Immunological and Serological Studies of Plant Lectins as Related to Blood Grouping. (Ohio)

17* Some Aspects of Marine Microbiology. (Texas)

The Armed Forces Chemical Association

Plaques and $50 toward transportation expenses to their U.S. Army job or trips to five of the persons named for U.S.

The Army Aviation Association

A plaque and $100 to two finalists.

17 Design of Autogyros. (Texas)

17 The Making of a Ramjet. (California)

The U. S. Navy

Ten finalists were designated as Navy Science Cruisers and awarded Principal Awards Certificates and official U.S. Navy binoculars in addition to science-oriented trips on U.S. Naval vessels and at land-based USN research facilities.

17 Determination of Suppressor Gene Loci in *B. coli* K-12. (Texas)

17 A New Concept in Metallic Crystal Structure. (Kentucky)

16 A New Nuclear Magnetic Interaction. (Massachusetts)

17 *Plasmodium berghei*: p-aminobenzoate. (Maryland)

18 Micrometeoroid Erosion and Spacecraft Materials. (Oklahoma)

16 Constructional and Operational Problems of High Speed Displacement Hulls. (Massachusetts)

16 A Machine which Duplicates the Learning Process. (Texas)

16 Effects of High 'G' on Living Things. (Washington)

15 Spark Chamber Construction and Operation. (Texas)

The U. S. Air Force

A plaque and expenses-paid trips to USAF research facilities and salaried summer jobs at research laboratories in the fields of the individual interests of 10 finalists in that many categories. Eleven alternates were named.

IN AEROSPACE BIOLOGICAL SCIENCES

16 Biochemical and Physiological Analysis of the Haemoglobin in *Daphnia magna* Strauss. (Texas)

IN AEROSPACE CHEMISTRY

17 Chemical Analysis by Infrared Spectrophotometry. (Montana)

IN AEROSPACE DYNAMICS

17 Design of Autogyros. (Texas)

IN AEROSPACE ELECTRONICS AND COMMUNICATIONS

16 Simultaneous Oscillations in Negative Resistance Devices. (Texas)

IN AEROSPACE ENVIRONMENTAL SCIENCES

17 Extratropical Cyclones. (Washington D.C.)

IN AEROSPACE MEDICINE

18 Hibernation *vs* Hypothermia. (Arizona)

IN AEROSPACE PHYSICS

16 Nuclear Quadrupole Resonance Effects. (California)

IN AEROSPACE PHYSIOLOGICAL AND SOCIAL SCIENCES

17* Sleep—a Habit? Rest—Necessary!

IN AEROSPACE PROPULSION

17 The Making of a Ramjet. (California)

IN MATHEMATICAL AND COMPUTATIONAL SCIENCES

17 Generalizations of Circular and Hyperbolic Functions. (Virginia)

American Dental Association

Certificates of Superior Achievement to two, both to be guests at ADA annual meeting. Certificates for Meritorious Achievement and $50 for scientific equipment to two others.

FIRST

18* Electrophoretic Investigation of Rabbit Plasma Proteins—Effects of PTH Injection. (South Carolina)

SECOND

18* Regeneration of the Caudal Fin in *Lebistes reticulatus*. (Oklahoma)

American Medical Association

Citation and plaques to two. Both to be guests at annual meeting of AMA. Honorable Mention, citations and plaques to two others.

FIRST

18* Rous Sarcoma: Preparation of Heat-Killed Vaccine and Antiserum. (Alabama)

SECOND

17 Thymus Research. (Indiana)

American Pharmaceutical Association

Plaque and choice of a trip to the annual

meeting of APHA or a cash award to further scientific education. Plaque for second.

FIRST

17 Antagonistic Effect of Snake Venoms on Staphylococcal Infection. (Florida)

SECOND

16* Effects of Tranquilizers on Turtle Heart. (Michigan)

American Veterinary Medical Association

Science Youth Award and an invitation to annual meeting of AVMA, to first; Meritorious Achievement Award to second.

FIRST

18 Electro-Anaesthesia in Small Animals. (Iowa)

SECOND

17 Sequential Replication of Chromosomes. (Texas)

Central Building Research Institute

STARTED as a Building Research Unit attached to the University of Roorkee in 1947, the Central Building Research Institute became a full-fledged National Laboratory in 1953. Research at the Institute aims at improving existing building materials and techniques, evolving new processes with a view to reducing construction costs and ensuring the economic use of materials. The work is organised under seven divisions: Building Materials; Soil Mechanics and Foundation Engineering; Efficiency of Buildings; Design and Performance of Structures; Architecture; Building Practice and Productivity; and Survey and Information. In addition, there is an Extension Cell with the responsibility of popularising the work of the Institute and getting its findings implemented in the building industry. Although the work is

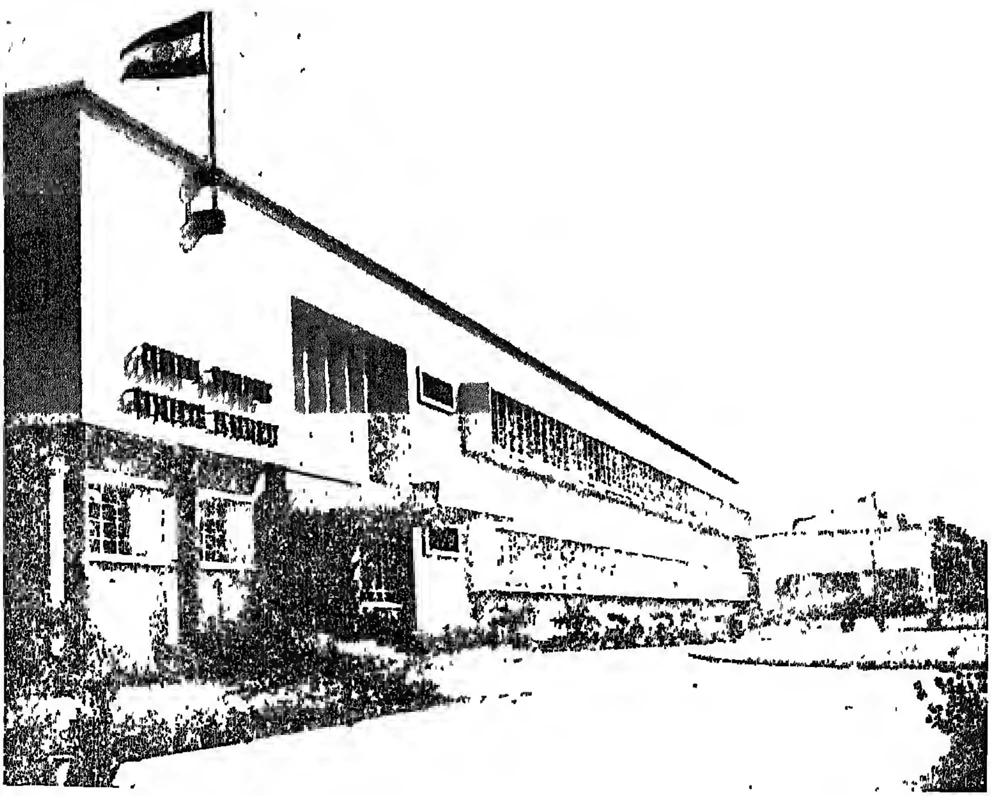

Fig 1. Central Building Research Institute, Roorkee

being carried on under various divisions for administrative convenience, many of the problems being tackled involve more than one division and the scientists and engineers working at the Institute are encouraged to join hands and bring an interdisciplinary approach, viewing the building as a whole. The Institute has at present on its rolls around 120 engineers and scientists.

Building Materials

For a long time to come, bricks will continue to be the cheapest material of construction for walls of houses. Although the technique of brick-making dates back to the Indus Valley civilization, the impact of technology on this art has been practically negligible. By and large, bricks continue to be made in traditional kilns as they were being done a hundred years ago. The Institute has carried out studies to improve the performance and thermal efficiency of the Bulls Trench Kiln. In many parts of the country, especially Madhya Pradesh, black cotton soil is encountered which is unsuitable for brick making. Techniques have been developed at the Institute to produce good bricks out of such soils by adding grog (partially calcined clay). The process has been successfully applied for the manufacture of bricks on a semi-commercial scale at Indore. Studies have also been carried out on problems of the tile industry and it has been established that the addition of ammonium chloride to clays effectively arrests the cracking and warping of tiles. Acid resistance bricks were produced from selected alluvial soil of the Indo-Gangetic plain by firing to a temperature higher than 1050°C.

Another programme relates to the production of light-weight aggregates from fly ash, a waste product of thermal power plants using powdered coal. Properties of concrete made out of such light-weight aggregates have been studied in detail. Studies have also been completed on the possible utilization of fly ash as a substitute for surkhi in lime puzzolana mortars and for partial replacement of cement in concrete. On the organic material side, the possibility of manufacturing particle boards from coconut pith has been successfully pursued. The wide possibilities of cashewnut shell liquid as a raw material for developing water-proofing and fire retarding coatings for plastics are being exploited

The current research programme includes new projects on mechanised brick making, protection of reinforcement in brick work, survey of clay deposits for the manufacture of bloated clay aggregates, acid resistant flooring materials, use of plastics in buildings, etc.

Soil Engineering

The under-reamed pile foundation for use in black cotton soil areas is the most remarkable achievement in Soil Engineering field. Structures built on expansive clays, like black cotton soil, often crack because of differential movement caused by alternate swelling and shrinkage of the soil. The under-reamed pile foundations designed by the Institute have proved satisfactory and economical for buildings in black cotton soil areas. Large scale constructions adopting this improved design have taken place and sufficient information on the technical know-how is now available. A further improvement of the process is the technique of double-under-reaming which has been found to increase the bearing capacity by 50 per cent.

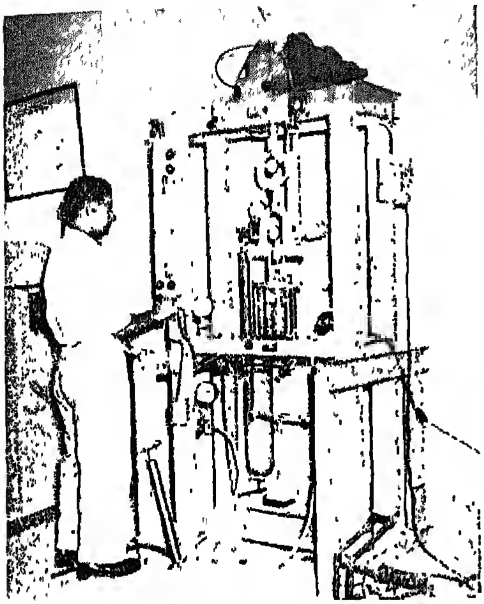

Fig. 2 Scientist engaged in triaxial shear test in Soil Mechanics Laboratory

Considerable research on the improvement of the design and performance of pile foundation has been made and reliable means of estimating the load bearing capacity of piles, without having to wait for the conventional and time consuming loading tests, have been developed. The Soil Engineering division has also assisted many large projects, such as the Antibiotics Project at Rishikesh, Explosives Factory at Nagpur, Hindustan Photofilm Factory at Ootacamond and a large number of CPWD and State PWD building projects, with complete project reports on soil investigation. Studies on well foundations and deep pile foundations have been included in the current research programme

Design and Performance of Structures

The accent of work in this division is on the use of improved structural forms like shells, and new material like prestressed concrete with the object of saving scarce materials like cement and steel. The precast doubly-curved shell roof developed at the Institute cuts construction costs, besides speeding up work and saving cement and steel. This form of construction found large scale application in the one-crore Amar Project at Ambala. Continuous folded plates developed at the Institute found application in roofing the Indo-Swiss Training Centre at Chandigarh This division has also assisted many organisations such as CPWD in the design of Gram Godowns, the Madras Port Trust in the design of pre-fabricated funicular shells for the floor of transit sheds, the Army in the design of the high-altitude hut and the Railways in designing railway platform roofs. It is well equipped to carry out tests to destruction on fullscale bridge and building components. A Computing Centre with an Electronic Digital Computer is also available for carrying out complex structural calculations.

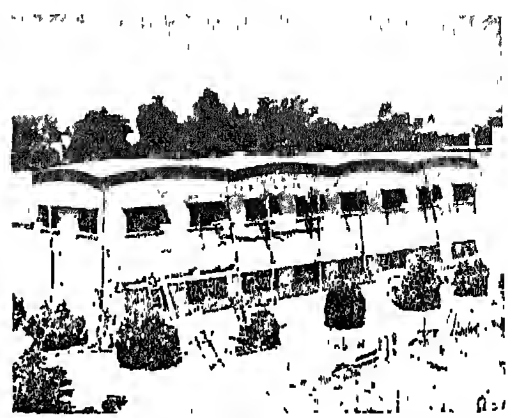

Fig. 3. A portion of Institute building with shell roof

New projects in this division include, design and development of prefabrication

systems, use of high strength friction bolts and studies on multi-storey buildings.

Building Practice and Productivity

This division concentrates on productivity research and assists the building industry by offering advice on construction problems.

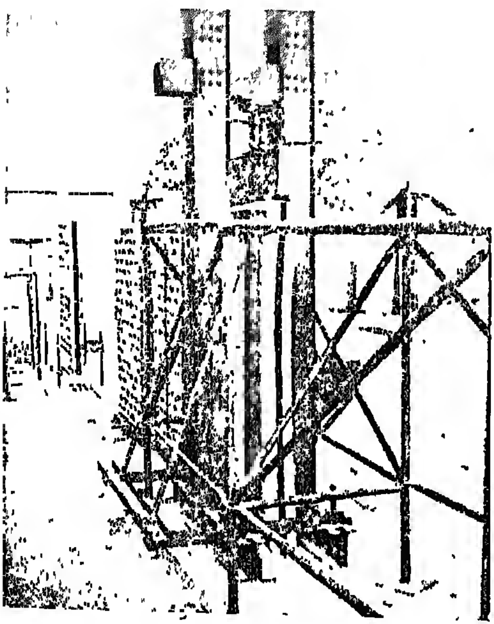

Fig 4 Cavity Well under Load Test

Studies on 8 in cavity wells (2 leaves of brick on edge with 2 in cavity) have revealed that they are structurally sound and can be readily adopted for load bearing walls in multi-storoyed construction. The development of a new type of precast hollow concrete unit with trapezoidal cells for flat roofs is another major achievement of this division. Tests carried out on these cellular roofing units indicate that they are suitable for use in non-industrial buildings subjected to liveloads up to 40 p.s.f. A masonry-saw developed as a substitute for imported saws has given satisfactory results. Work studies have been carried out with the object of improving the efficiency of laying RCC slabs and building cavity walls.

New projects in this division include, single stack system of plumbino, work studies on output and gang sizes of skilled and unskilled labour, trends of costing patterns in buildings, etc.

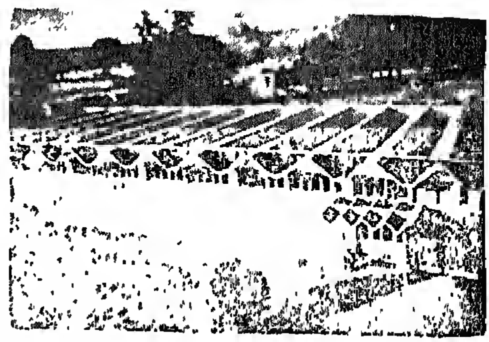

Fig. 5. Museum building showing folded plate roof

Efficiency of Buildings

The bulk of the programme in hand is devoted to comfort studies on buildings. As the proper orientation of buildings can make all the difference in so far as comfort is concerned, the division has compiled a comprehensive Solar Atlas which helps the Engineer in selecting the best orientation at any given location in India with due regard to humidity, temperature and the direction of prevailing winds. Data were collected on the thermal responses of full scale test houses and supplied to the air-conditioning industry. Remedial measures for noise abatement are being studied and the functional absorbers developed at the Institute may offer a possible answer.

Studies have also been carried out on the optimum slopes of North Light Roofs to provide uniform illumination in factory buildings with different bay widths. Data on the measured noise levels in factories having a variety of heavy machinery have been collected with the object of determining their spectral distribution and loudness levels.

New projects include rain protection devices on windows, utilization of solar energy for heating and refrigeration and development of electronic instruments for flaw detection in metals.

Architecture

One of the research programmes in architecture relates to the choice of dimensions of classrooms for primary schools. Based on anatomical measurements of children in the local primary schools, the optimum size of a class room has been found to be 20 ft. x 20 ft. accommodating forty students. Another study in progress relates to the design of vertical and horizontal accesses to multi-storeyed residential flats.

Survey and Information

This division handles information, public relations and publicity, publications, library and documentation, industrial surveys and operational research. It acts as a liaison with outside bodies and agencies and disseminates information on the work being done at the Institute. At the same time, it is in constant touch with building research laboratories all over the world and attempts to keep its scientists informed of the research going on elsewhere. Industrial surveys in the field of building industry have been included in the programme.

Other Activities

Besides conducting research on problems of the building industry, the Institute functions on the Committees of Indian Standards Institution and helps it in framing standards and codes of practice. It works in close collaboration with organizations such as the National Buildings Organization and various committees of the Building Projects Team of the Committee on Plan Projects. At the international level, the Institute functions on the working groups set up by the C.I.B. (International Council for building research studies and documentation). It also influences the profession and popularises new processes and techniques by holding periodical symposia on subjects of current interest.

Research and Training Facilities

The Institute possesses the latest equipment and amenities for advanced research in the fields of soil mechanics, structural engineering, acoustics, heat transfer, illumination and chemistry of building materials. An I.B.M. 1620 Digital Computer has recently been installed.

Senior and junior research fellowships are offered to young scientists and engineers with good academic record to help them to acquire training in research methodology. Apprenticeships are offered to graduate scientists and diploma holders in engineering.

During the vacations, university teachers are invited to avail of the research facilities. Similarly, scientists and engineers engaged in other institutes or the industry are welcome to take advantage of training and testing facilities.

Advanced courses on specialised subjects are occasionally organized.

Library

A well stocked library is maintained and special publications including reports, reprints, proceedings, etc., are quickly procured from all parts of the world. At present, the total number of books and other scientific publications held in the library exceeds 20,000. The library receives about 400 periodicals from all over the world.

Efficient documentation and other special library services like translation, photo-reproduction, etc., are provided to research workers. Special project-oriented bibliographies are prepared.

Publications

The Institute publishes, for wide circulation, *Annual Reports* summarising the progress of research. The Institute brings out a series of Building Digests and Building Materials Notes summarising available information on selected building topics for the use of engineers and architects in India. Other publications in the form of manuals on specialised building techniques are brought out occasionally. The proceedings of symposia held in the Institute are published which contain the papers presented and the discussions thereon.

Museum

The Institute maintains a museum for exhibiting, through models, charts, tables, photographs and samples, the progress of research. A large number of visitors including students from universities and institutions visit this museum and arrangements are made to explain and demonstrate the various exhibits.

Classroom experiments

CONVERTING HEAT ENERGY INTO ELECTRICAL ENERGY*

A thermocouple converts heat energy into electrical energy. To demonstrate that electricity may be generated from heat, make a thermocouple and connect it to a galvanometer as shown in the figure. Take a piece of iron or nichrome wire about one metre long, and two pieces of copper wire. Snap the ends of the wire clean and twist the copper wires to the iron or nichrome wire as shown. Heat one of the junctions on a bunsen flame and coil the other end in ice-water. Observe if a current flows through the galvanometer.

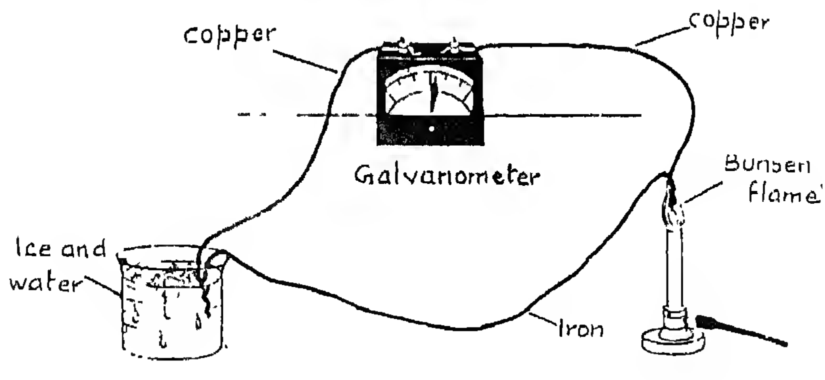

Fig 1 A thermocouple

MAKING AN ELECTROMAGNET*

An electro-magnet is made by winding a wire in a coil about a piece of iron and passing a current through the wire It can be made stronger by adding more coils of wire or by passing more current in the coils. Its poles can be reversed by changing the direction of the current flowing in the coil of wire.

1. To make an electro-magnet, wrap many turns of an insulated wire around a soft iron bolt. There should be from 25 to 100 turns of wire. Number 18 copper or aluminium wire works well. The insulation may be enamel, plastic or rubber.

2. To see how this electro-magnet works, connect a dry cell to it and see if the magnet will pick up paper clips. Release the circuit. What happens? (Caution: Do not keep the magnet connected to the dry cell long, for it will run down the dry cell).

3. To see how an electro-magnet can be made to attract more, connect two dry cells in series with the magnet you have made. Compare the number of paper clips it picks

* From *General Science—Handbook of Activities (Classes VI—VIII)*. NCERT, New Delhi, 1964.

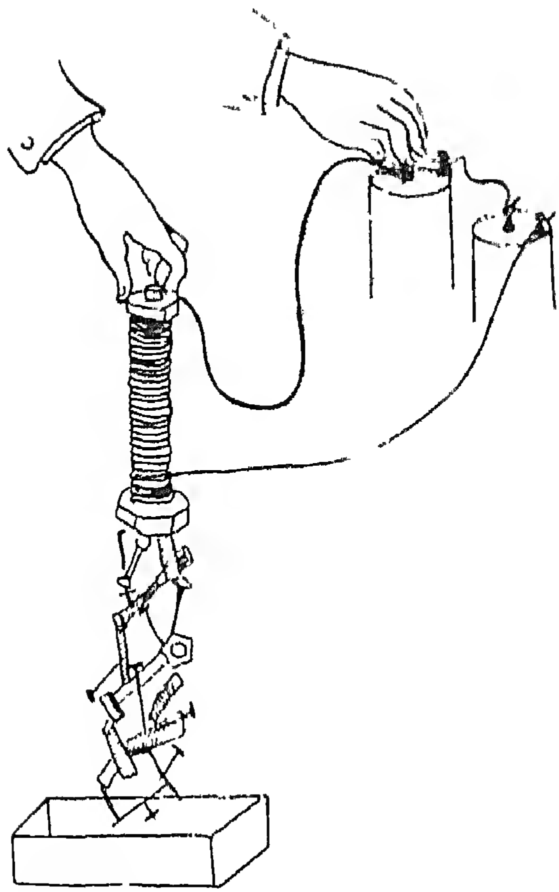

Fig. 2. Making an Electr-omagnet

up when connected to one cell with the number it picks up when connected to two cells.

Make a second electro-magnet with more turns of wire than those on the first. Connect this larger electro-magnet to one cell and compare the amount it picks up with the amount the small electro-magnet picked up when connected to one dry cell. In what two ways may the attraction of electro-magnets be increased?

4 To find out how to reverse the poles of an electro-magnet, bring a pole of one electro-magnet near a compass needle and identify it as being a north or south pole. Then change the connections on the dry cell so that the current flows through the electro-magnet in the opposite directions. Test to see if the poles are the same. How does one reverse the poles of an electro-magnet?

Science abroad

Science Education—East Africa

Zachariah Subarsky
Kairodi Science Teaching Centre, Nairobi, Kenya

PATTERNS of education—yes, even of science education anywhere in the world—are distinctive, and each is geared to the culture of which it is a part. Cultural patterns, generally, come into being through 'natural selection', so to speak. Most of their features are functional and have 'survival value', others are mere vestiges.

In East African countries, teachers are examination-minded and students are certificate-minded. The efforts of a science teacher are forcefully directed to getting as many students as possible to pass the Cambridge School Certificate examinations, and the goal of every student is not so much to learn, as to gain a school certificate.

Before we condemn this psychological state of affairs, we should try to understand and appreciate its origin. In early colonial days, schools were established under a bewildering variety of auspices There were missionary schools, government schools, government-aided schools. There were schools run by Dutch sisters, Italian fathers, American brothers. There were, in fact, virtually three school systems—one for Africans, another for Asians, and still another for Europeans. If there were not some such umbrella as the Cambridge School Certificate examinations to set a standard, educational chaos would have prevailed

Even today under political independence, with new schools springing up like mushrooms, some such umbrella is still needed. The strong influence of external examinations on science teaching is therefore likely to persist for many years to come. Also persistent will be the arrangements and patterns of science teaching. How do these arrangements and patterns differ from those in the United States ?

The science programme for students in our American high schools may be described as being horizontally arranged. The unit of time for a science subject is the year. Thus a student may take general science in his ninth year, biology in the tenth year, physics in the eleventh, and chemistry in the twelfth. At the end of each year, if the student passes, he goes on to take another science subject. It is not so in the school systems of the former British colonies. In these systems the science offerings may be described as being arranged vertically.

In the British system, the unit of time for a science subject is a four-year period. Thus, a student may take biology for four years and, concurrently, take physics for four years and chemistry for four years. Such a student would be taking three science subjects all through his secondary schooling.

Reprinted from the *Science Teacher* 32 (2) . 40-41, February, 1965.

For some students this programme is modified—or rather contracted to two subjects: biology and physics with chemistry, the latter constituting a single science subject. For still other students, a further contraction is made, and all three subjects are included under the name general science. In any case, each of the science subjects is taken for four years and is terminated by an external examination. Some students take three science examinations, some, two and some, only one

More Time for Science Instruction

A scrutiny of the Cambridge syllabuses reveals that the physics with chemistry course is not what you might expect—a truly integrated course in physical science. Rather, it is the physics course and the chemistry course put together and certain topics from each deleted Nor is the general science course an integrated one. It consists essentially of topics selected from the other three courses—biology, chemistry, physics

Both the horizontal and vertical arrangements have their advantages. The vertical is best suited to a system which aims to promote and encourage early specialization, and it provides more curricular time for science instruction An American student taking the conventional sequence of science subjects has a total time for science instruction over the four years of 800 periods. A student in Kenya taking three science subjects for four years would get 1,621 periods of science—more than twice the American number. Of course, there is variation in amount of time in both countries. However, the student in Kenya, even if he takes only two science subjects, gets over 25 per cent more science instruction time than does an American student Only the student taking the single general science course in Kenya would get less time than the American student

It would appear that, potentially, at least, there might be other advantages to the vertical arrangement For example, correlations among science subjects could be achieved However, I have seen little evidence that this advantage is actually worked into the programme of instruction A student may study diffusion and osmosis in chemistry, again in physics, and yet again in biology, without as much as being aware that he is studying the same phenomenon

Another possible advantage is the possibility of studying a given topic 'spirally'—again and again over the four years, but each time on an ever higher level commensurate with the student's growth, maturation and experience. However, the official syllabus gives no guidance to the teacher on how to do this Neither do the textbooks.

In surveying the printed syllabus, one looks in vain for statements of concepts and generalizations so familiar in American syllabuses as goals of science teaching. What the Kenya student is to learn is set down in hard topical terms. Nor does the printed syllabus provide any guidance to the teacher on the order of teaching the various topics. The syllabus merely defines that for which the examination will hold the student responsible. The teacher is expected to arrange the order of topics.

Teacher Orientation

Under the British system, a secondary school teacher is not licensed to teach any

given subject. If he has a university degree, he may legally be assigned to teach any subject in the secondary school curriculum Naturally, headmasters use their discretion and make assignments in line with a given teacher's training and experience. Methods courses are not a pre-requisite, and most teachers who have not been exposed to methods courses tend to teach as they themselves have been taught.

Most science teachers in Kenya are non-graduates who themselves have never gone beyond O-Level (equivalent to high school) in their education. The Ministry of Education is compelled by circumstances to assign such teachers to teach in secondary schools. These teachers are none-the-less professional minded and eager to do a good job Unfortunately, the Cambridge syllabus placed in their hands does not contain sufficient guidance for these teachers.

To remedy this situation, the Nairobi Science Teaching Centre has undertaken to produce four-year schemes of work for biology, physics and chemistry. Schemes for the first two years of biology and the first two years of physics-with-chemistry have already been produced and are now being used in secondary schools of Kenya, Uganda and Tanzania (Tanganyika). The scheme for year-three biology is completed and will soon be distributed.

Each of these schemes is based strictly as, indeed, it must be, on the Cambridge syllabus. But the content as well as suggested teaching methods are spelt out in great detail Each scheme is virtually a set of daily lesson plans, and the teacher learns along with his pupils.

We hope these schemes will serve to reorient teachers in their professional work and to breathe new life into the science-learning experiences of pupils in East African secondary schools.

Examination Orientation

Secondary education under the British system (which still prevails in former colonial countries) is overwhelmingly 'college-dominated'. Instruction is geared to examinations constructed and rated by university syndicates. (There is a strong movement in former colonies, indeed, even in the United Kingdom itself, to disengage instruction from these examinations.)

In the Kenya school system, the first major hurdle to be overcome by children is the KPE (Kenya Preliminary Examinations) These correspond to the 11-plus examinations in Great Britain—so called because they are taken by children at the age of eleven. For the child who fails KPE, formal education usually comes to an end. Understandably, each year, as the time for KPE approaches, children—and especially their parents—become increasingly tense and worried.

Children who pass KPE become eligible to go on to secondary school. But they are not admitted automatically, both because of the insufficient number of secondary schools and the school fees Consequently, headmasters select the best students who are able to pay fees or for whom bursaries (scholarships) are available.

Once in secondary school, the boy or girl becomes a candidate for the 'O-Level' (Ordinary Level) examinations to come four years later. Schemes of work are closely aligned to these examinations They had better be, for the school itself is ultimately

judged by the number of 'passes' it obtains. Moreover, a teacher dare not depart very far from the examination requirements, for students can obtain the printed syllabus in any good bookshop, and they have been known to protest to the headmaster, or even to threaten a strike, because the teacher was teaching them something that is not in the syllabus.

This attitude is understandable when you consider that the O-Level Certificate is the student's only passport to further education. Furthermore, most African students are maintained in school through fees contributed by parents, uncles, aunts, and other relatives who, under culture pressures, are obliged to contribute. The African student is serious and means business.

Even if it is not used as a passport to further schooling, the O-Level Certificate has great economic value. I once had occasion to be waiting in the office of a women's employment agency. During this time, phone calls kept coming in from job seekers and from employers. The pivotal question I heard over and over again was 'What school certificate do you hold?' or (to an employer) 'What school certificate do you require?' If the applicant does not hold the proper certificate, other questions of skill or ability become irrelevant.

To obtain the O-Level Certificate, the student takes examinations in four, five, or even six subjects. He may obtain 'passes' in one, two, or three, and fail in the others. Institutions may require entrants to have at least three passes.

To enter a university, the student needs more than the O-Level Certificate. He must have passed through a programme of further education leading to a 'higher' school certificate. More secondary schools are O-Level schools; a few, however, are 'sixth-form' schools which extend secondary schooling for one, two, or three years longer than the four years of the O-Level schools. A few schools are exclusively sixth-form schools, that is to say, they gather their students from among graduates of O-Level schools and only sixth form courses are offered.

Sixth form work is on a high level—easily comparable to offerings in fresh-man and sophomore courses in American colleges. But the work is relatively rigid and inflexible.

In schools having both O-Level and sixth-form classes, the sixth formers constitute the elite of the student body. They are given privileges commensurate with their maturity, and from their ranks come the 'prefects'—right-arm aides to the headmaster.

The Future

Will the pattern of education in former colonial countries change with political and social evolution? Changes will undoubtedly take place, but the general pattern of schooling, like the parliamentary pattern of government—both inherited from the British—is likely to be maintained. A local University Examinations Syndicate will probably be substituted for the Cambridge and London University Syndicates. Syllabuses may be revised so as to reflect more closely national conditions and national needs. But examinations will continue to be the strongest influence on the programmes of secondary education, and 'certificates' will continue to play a crucial part in the lives of young people in those countries. It is far easier to demolish structures of steel and concrete and replace them than to change established patterns of culture.

Children Thrive on Maths Revolution

John Dalin

A STORM of new ideas about teaching mathematics is sweeping the primary schools of Britain, and there can be very few teachers of young children who are not caught up in it.

Some teachers are downright 'revolutionary', and new vistas in mathematics, far beyond the experience of their parents, are being opened to a lucky minority of children.

Most people agree that the early stages of mathematics teaching leave much to be desired.

Brilliant mathematicians, who have emerged, have survived rather than profited from their early mathematical tuition! Counting and money sums in Britain, based on a complicated system of units, have been the order of the day, and the aim appears to have been to produce competent ledger clerks rather than to impart genuine mathematical experience.

But now, ideas are changing rapidly. Among the leaders of the drive to change them Dr. Caleb Gattegno, a Spanish mathematics teacher of some eminence, settled long in England. It was he who introduced to Britain the cuisenaire rods, which together with the 'colour factor' rods derived from them, are being used experimentally both as aids and as a more substantial basis for all mathematics teaching in a growing number of schools.

Cuisenaire rods stem from the work of Georges Cuisenaire who, as a Belgian teacher of young children, used rods of varying length to convey the concepts of number. Today the apparatus consists of a series of rods of one centimetre square cross-section, whose lengths, in centimetres, correspond to the number they represent

There are ten of them. They are variously coloured, the colour being used for two reasons. First, it is an alternative to the number (thus light green equates with three): second, it is a theme in that 2, 4, 8, for example, all obviously contain some red in their make-up.

The actual colours are 1—natural, 2—red, 3-light green, 4—magenta, 5—yellow, 6—dark-green, 7—black, 8—a reddy-brown, 9—blue and 10—orange. The children would thus express an easy addition, as a red and a light green joined together equate with a yellow ($2+3=5$). Multiplication is expressed by crossing one bar on top of another so that a light green crossed by a red produces a dark green ($2\times3=6$) The multiplication would also be expressed by showing that a 'train' of three reds or two light greens are both equal in length to a dark green.

Colour factor, developed in Britain, carries the colour idea a stage further. There are twelve rods with 1, the universal factor, in white The rest are 2—pink, 3—blue, 4—red, 5—yellow, 6—mauve, 7—grey, 8—a

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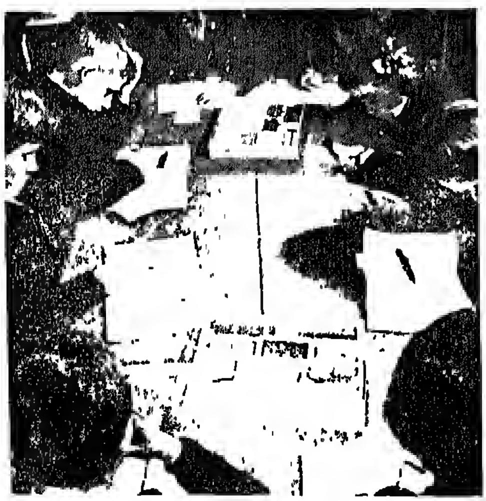
deeper red, 9—a deeper blue, 10—orange, 11—grey and 12—mauve.

Addition and subtraction relying on the lengths of rods are carried out in the same way as with Cuisenaire rods, but the theory is that multiplication is conveyed by the addition of colours. Thus 2×3 is represented by pink $\times$ blue and the 6 rod is mauve. From his own paint-box the child can demonstrate that pink mixed with blue does indeed give mauve.



Rapt faces bent over maths problems holding the success new methods can have in illustrate attention These children are pupils at All Saints Primary School, Beulah Hill, London.

Prime numbers, which have no factors, are represented in colour factor by deepening shades of grey, and as all the numbers become larger so they become darker.

How relevant are the colours? Teachers disagree on this point. Some maintain that children who have learnt to count white, red, light-green and so on have difficulty in translating back to words one, two, three. Others imply that the colour gradations in colour factor are extremely subtle and are beyond the capacity of young children—especially the boys, whose colour sense lags behind that of the girls'. Whether or not the colour subtleties are admitted, there is no doubt that leaving the children to estimate the lengths of various rods by eye leaves something to be desired and the colours provide a useful means of identification.

Children starting with the coloured rods are first left to play freely with them so as to familiarise themselves. Guidance is at all times kept in the background, and general instruction is very limited. The children go through the stages of making 'trains' and equating the lengths of various combinations of the rods, thus finding out factors and many number bonds for them selves. For example, they discover that seven plus three, or six plus four, all make ten. Block patterns made from the rods demonstrate the same point.

At the same time they can match, say, five single units with a five rod, thus demonstrating the two concepts of a number that it is both a collection of units and a group measurement in its own right. Adding, multiplication, division and simple fractions follow quite logically—all of them based on practical experience with the rods.

Those teachers who have committed themselves to either method carry it to a very advanced degree, using the rods as areas or volumes to convey quite complicated algebraic idea (for example, the difference of two squares) with a lot of success. But in practice, most teachers use the rods as an aid and tend to wean

the children from them at the eight to nine-year old stage.

What is evident to an observer is the complete absorption of a group of children engaged on working with the rods. At first it appears as undirected play, but direction and purpose soon become apparent. Calculation is achieved and subsequently recorded, and all the time difficult mathematical concepts are being learned without tedious and often misleading explanations.

Among the more intelligent children a high degree of skill develops and difficult problems can be solved with the rods moving purposefully to the conclusion of the problem.

The effect on an outside observer is much the same as watching an aircraft pilot with his controls and dials—what he is doing is unintelligible but obviously skilful, and the final result is immediately apparent.

There is little doubt that children taught by these methods gain mathematical intuition—often their masterly handling of what most children regard as difficult problems amply demonstrates this. Where they lose is in the handling of complicated weights and measures, largely because of unfamiliarity and the time involved.

Many teachers have adopted a compromise solution attempting to mingle the old with the new. As in much modern teaching, practical considerations count and parents and some teachers are not always as ready for new ideas as others.

The coloured rods have a powerful attraction and obvious value, but they are not the only forms of apparatus available and many new ideas are constantly appearing. All are the subjects of some argument, but the reassuring element is the now common urge for experimentation to find ways of improving what had come to be regarded as a thoroughly unsatisfactory mathematical teaching situation.

Teaching of Chemistry at Soviet Schools

V. A. Gluoshenkov

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CHEMISTRY is the science of substances, their transformations and the manifestations accompanying these changes.

Nowadays, chemistry presents a vast and rapidly developing branch of science. Revealing the laws of conversion of some substances into others more complicated, chemistry makes it possible to scientifically comprehend changes and development permanently taking place in nature. Explaining the essence of processes proceeding in organisms, chemistry helps in comprehending the material basis of life. Chemistry not only explains the world, but also facilitates its changing. The knowledge of the laws proceeding in chemical reactions helps man to employ them in the artificial production of many substances.

Chemistry as a compulsory subject is taught in Soviet schools from class VII onwards. The tasks of the course of chemistry at middle school envisage giving pupils the initial information of the properties of some most important chemical elements and their combinations, types of chemical reactions, fundamental chemical laws ; equipping them with abilities of handling substances, chemical apparatus and conducting very simple chemical experiments; giving them notion about the role of chemistry in national economy and the most important paths in the development of the chemical industry in the USSR.

The main tasks of teaching chemistry at secondary school are giving pupils the systematized knowledge of the bases of science, guaranteeing their understanding chemical facters in the light of the leading chemical theories ; building up their scientific outlook ; making pupils acquainted with the most important chemical enterprises and the role of chemistry in other fields of production ; developing in them abilities to examine and explain chemical phenomena happening in nature, laboratory, production and in everyday life ; further developing in pupils abilities to handle substances and conduct chemical operations

As shown below the course of chemistry has a concentric structure. It is explained by the fact that middle school must provide pupils with the completed course of knowledge of chemistry.

The basis of any science about nature consists of most fundamental laws, main theories, giving explanation to these laws, and most important factors contributing to comprehending laws and theories. The choice of most important factors, laws and theories of any branch of science must guarantee a further broadening and deepening of basic knowledge with the preservation at the same time of its fundamental character, meanwhile the knowledge got as a result of studying the bases of science must be sufficient enough to independently comprehend new, most essential phenomena in this field.

The atom-molecular study constitutes the theoretical basis of the course of chemistry at middle school. Pupils get the initial notion of the molecular structure of substance at the lessons of physics in class VI, that is why this problem is not included into the first theme of the syllabus, but pupil's knowledge of the principles of the molecular theory should be employed by teacher when he introduces changes of substance, substances and their properties, pure substances, mixtures and solutions.

Since chemistry studies substances and their conversion the course of chemistry at school starts with introduction of the notion 'substance' on the basis of the things surrounding us in our everyday life. Simultaneously with the introduction of the notion 'substance', pupils are given the notion of the properties of substance. The molecular theory gives explanation to the conversion of substances from one state into another The notion of the molecular structure of substances and the main principles of the molecular theory are given here. The notion of chemical conversion (reactions) is given both in comparison and opposition, i.e, the notion 'chemical phenomenon' is more comprehensible when opposed to the notion 'physical phenomenon'. To make teaching more accessible chemical phenomenon is differentiated only as 'reaction of decomposition' and 'reaction of combination'. The essence of chemical reactions lies in the change of the composition of the molecule. That is why the basic principles of the atom-molecular study are obligatorily given. On this basis the notion of element, the law of conservation of mass of a substance, chemical formula and chemical equation are introduced. After learning the basic chemical notions and getting acquainted with the atom-molecular study it becomes possible to examine substances.

Study of substances starts with oxygen, for pupils have already some notion of oxygen, air and water from the courses of natural history and botany. On the examples connected with oxygen pupils get more profound knowledge of atom-molecular study, chemical terminology, oxidation, oxides and valency. All this provides for studying the composition of the air. Knowledge of the properties of oxygen, oxides and the composition of the air contributes to studying hydrogen. Its reducing properties are studied on its interaction with oxygen and oxides of metals. Water being the product of the oxidation of hydrogen can now be thoroughly examined. All this lays a solid foundation for studying oxides, bases, acids and salts.

Proceeding from the material studied in class VII, pupils are given in class VIII the main classes of inorganic combinations. General properties of oxides, bases, acids and salts may be now imparted. To broaden pupils' knowledge of the role of chemistry in national economy the class VIII syllabus envisages the studying of mineral fertilizers (logical continuation of the theme on the main classes of chemical combinations); carbon (including the elementary knowledge of organic substances as well as carbohydrates, fats, proteins) important from the point of view of biology, metals and at last chemistry and its place in national economy.

The course in chemistry at secondary school is based on the course of the general chemistry of middle school and consists of two principle parts, inorganic and organic chemistry, which are studied in succession.

The periodic law and the periodic system of chemical elements of D. I. Mendeleyev and the theory of the structure of the atom constitute the scientific basis of the course of inorganic chemistry at secondary school, and that is why the study of these problems is placed at the beginning of the course of inorganic chemistry at secondary school.

A great deal of attention is paid to the choice of the elements of the periodic law which are studied at school. D I. Mendeleyev suggested, and that has been proved by the experience of teaching chemistry at Soviet school, that the periodic law is best taught on the examples connected with short periods as the periodic change of the properties of these elements is not complicated. The elements of the short periods are typical elements, characterized by well-expressed properties, the knowledge of which may become the basis for understanding the properties of the elements of the same groups.

Studying all the elements of the short periods is not obligatory. The reiteration of properties constituting the basis of the periodic law, it is sufficient to study on the one hand the properties of one of the alkali metals (for example sodium) which occupies the first place in any period, and on the other hand, the properties of one of the halogens (for example chlorine) plus one of the inert gases which crown any period.

With a view to get acquainted with the groups of elements some other representatives of the principal sub-groups are studied—metals : calcium, aluminium, iron After metals come non-metals, that is the representatives of the principal sub-groups: oxygen and sulphur, nitrogen and phosphorus are studied and lastly carbon and silicon pave the way to studying organic chemistry.

The course of organic chemistry has for its foundation the successive application of A. M. Butlyerov's theory of the chemical structure of organic substances. After accumulating certain factors requiring theoretical explanations, pupils are given A. M. Butlyerov's theory of chemical structure. The first factors requiring such explanations appear with studying homologous series of saturated hydrocarbons and their isomerism. After it the theory of structure is employed as scientific means for comprehending the chemical properties of organic substances

Classes of combinations of organic chemistry are chosen with a view to trace on their examples the development of substances from most simple to most complicated ones. All this plus the employment of the theory of structure must be examined by pupils on a school subject. Hence the course includes a number of classes of combinations forming the following themes: hydrocarbons (saturated, unsaturated, aromatic), alcohols and phenols, aldehydes, carboxylic acids (saturated, unsaturated), esters and fats, carbohydrates, nitro-compounds, amines, proteins. In studying these classes pupils get acquainted with the principal type of carbonic chains of molecules, various types of carbon-carbonic bonds (simple, double, triple) and principal functional groups.

Teaching of chemistry at Soviet school is based on rich experiment. The syllabus envisages three kinds of chemical experiment. 1) demonstrations, 2) laboratory experiment conducted by pupils as teacher is introducing new material, 3) laboratory work conducted

by pupils to complete the studying of the theme. Besides, the syllabus includes certain experimental problems which require a rather high-level theoretical knowledge and skill of experimental work (preparation and extraction of substances, identification of substances and proof of their composition). For establishing contacts between chemistry and life each theme of the syllabus obligatorily envisages excursions.

The attached contents of the course of chemistry displays the themes studied at Soviet school.

CHEMISTRY AT MIDDLE SCHOOL

VII Class (72 *hours*)

1. Substances and the changes they undergo (8 hours)
2. Elementary information of the structure and composition of substances (14 hours)
3. Oxygen, air (14 hours)
4. Hydrogen (6 hours)
5. Water and solutions (8 hours)
6. Oxides, bases, acids and salts (16 hours)
7. Excursions (6 hours)

VIII Class (70 *hours*)

1. Important classes of inorganic compounds (24 hours)
2. Mineral fertilizers (8 hours)
3. Carbon and its compounds (15 hours)
4. Metals (15 hours)
5. Chemistry and its importance in the national economy (4 hours)
6. Excursions (4 hours)

CHEMISTRY AT SECONDARY SCHOOL

Inorganic Chemistry (170 *hours*)

1. Fundamental ideas and laws of chemistry (10 hours)
2. Alkali metals (6 hours)
3. Halogens (19 hours)
4. The periodic law and the periodic system of chemical elements of D I. Mendeleyev. Structure of matter (18 hours)
5. Solutions. Theory of electrolytic dissociations (22 hours)
6. Metals (30 hours)
7. Oxygen and sulphur (18 hours)
8. Nitrogen and phosphorus (27 hours)
9. Carbon and silicon (14 hours)

Organic Chemistry (78 *hours*)

1. Subject of organic chemistry (1 hour)
2. Hydrocarbons. Butlyerov's theory of chemical structure of organic substances (30 hours)
3. Oxygen containing organic compounds (28 hours)
4. Nitrogen containing organic compounds (11 hours)
5. Achievements of organic chemistry (8 hours)
6. Review of chemical elements (10 hours)
7. Excursions

Teaching of Physics at Soviet Schools

A. V. Brioukhanov

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THE twentieth century and especially the second half of it is characterized by a rapid development of science. The application of science is becoming a decisive factor in the development of the productive forces of society. Perspectives of further progress are conditioned now by the achievements of the key branches of natural sciences. We witness a great reorganization of nature that impels people to comprehend and realize events, attracts their attention to science. And naturally knowledge of physics is one of the leading factors in the system of general, polytechnical and vocational education. In Soviet schools physics is a compulsory subject. As an independent subject physics is taught from class VI onwards, but the pupils get in junior classes most simple information of nature surrounding us.

The elementary course of physics taught at middle school includes the system of initial information in the field of machanics, heat, light, electricity and most general knowledge of the structure of matter. The choice and the contents of the enumerated parts are determined by the following:

(1) Physics as a subject at middle school must give pupils a complete system of general and polytechnical knowledge, supply them with a number of practical skills and abilities essential for life, promote the formation of scientific world outlook, inculcate love and respect for labour, guarantee conditions for further general and special education.

(2) The given material must be easy for the comprehension of pupils. It goes without saying that at middle school it is quite impossible to exhaust entirely the substance of physical theories and give a full explanation of the studied phenomena, but at the same time deepening and broadening further the pupils' knowledge should be guaranteed. No reteaching should take place.

(3) The succession of the material is conditioned by a logical development of physical concepts and by the community of the physical nature of the phenomena. The knowledge got by the pupils should lay a good foundation for the study of the other succeeding parts of physics.

(4) Maximum possible interrelation between different subjects should be gauranteed.

In class VI pupils are given initial knowledge of physical bodies, physical quantities and their measurement; properties of solids, liquids and gases; simple thermal phenomena[1]

1. Measuring of temperature, thermal expansion of bodies and heat conduction.

and a very primitive notion of molecules and their motion. In class VII pupils get an elementary knowledge of mechanics[2] and deeper information on heat.[3]

In class VIII they study at first sound[4] and light[5], and electricity[6] last.

The contents of the course are contributing to building up in pupils the concept of the material nature of the world; the interrelation of its phenomena; the possibility of knowing the laws of these phenomena and their application in practical activity. The problems of the structure of matter, the conversion of substance from one aggregate state into another, the electric and magnetic fields, the structure of the atom assume a great significance in this content. Pupils' studying equality of work on simple mechanisms, conversion of kinetic energy into potential and vice versa, mechanic equivalent of heat, Joule–Lenz's law leads to the comprehension of one of the most principal laws of nature—the law of conservation of energy.

With the purpose of effecting the connection of theory on the one hand with practice and the polytechnical training of pupils on the other the course of physics at middle school contains the following themes and problems : composition of forces and equilibrium, simple machines (lever, fixed and running flocks, windlass, inclined plane, train of gears and belt drive) device and operation of hydraulic machines, heat and electrical engines, means of transmitting energy at a great distance, means of communication (telephone, telegraph), certain physical and mechanical properties of materials used in building, elasticity and plasticity, simple electrical chains, electromagnetic relay, etc.

The succession of arranging themes in the course envisages inter-subject connections. For example, the initial knowledge of the structure of matter given in class VI is required for studying chemistry in class VII. Studying sound and light phenomena in class VIII helps pupils in studying organs of sight and hearing in the course of anatomy and physiology of man. At the same time the knowledge of electricity is quite necessary for carrying out tasks in electromechanics in the workshop in the last term of class VIII.

At the same time certain requirements of physics are, at the proper time, met in the course of mathematics—calculating volume, approximating numbers, trigonometrical functions, etc.

Laboratory work, demonstrations, films and excursions contribute to a deeper conscientious approach to physics, develop in pupils not only keenness of observation but, which is more important, the aspiration to find out the cause of a phenomenon, comprehend its origin and give answer to all the 'whys'. Pupils get acquainted

2. Transverse and rotational motion, uniform and non-uniform motion, slide friction and rolling, inertia of bodies, composition of forces and equilibrium, work and mechanical energy, mechanisms.

3. Heat and work, conversion of substance from one aggregate state to another, heat engines.

4. What is vibrational movement (examples), objective and subjective characteristics, of sound, reflection of sound, resonance, notion of recording and reproducing sound

5. Geometric optics, optical tools, dispersion.

6. Electrostatics, current, work and power of current, electromagnetic phenomena, elementary notion of radio and the structure of the atom.

with a number of widely spread devices and means of measurement in practice, and carry out a lot of calculations. And naturally all this leads to establishing close contacts between physics and life and to the forming of practical habits and abilities.

Thus physics at middle school gives pupils a logically completed amount of knowledge that reflects all the main ideas of modern physics. At the same time this course gives a good foundation for a further and more profound study of physics at secondary school.

The tasks of secondary school are to give pupils systematic knowledge of the bases of physics: mechanics, vibrations and waves, molecular physics and heat, electricity, optics and structure of the atom. All this is based on leading physical theories. Special attention is paid to studying the structure of substance/molecular—kinetic and electronic theories, theory of the structure of the atom and the atomic nucleus and the properties of various fields/gravitational and electromagnetic. All this is successfully used in studying molecular physics, thermal, electrical and magnetic phenomena, quantum properties of light, nuclear reactions, cosmic flights, etc.

One of the most significant factors of establishing contacts of physics with life is studying physical bases of modern industrial and agricultural production, up-to-date technological processes, perspectives of the development of physics, techniques and production. The course of physics envisages studying physical bases of energetics—production, transmission and use of electrical energy—different types of engines, processes of splitting the nucleus and use of nuclear energy. Pupils study the theoretical bases of cosmic flights, communication (radio, television), automation, technological processes (electrolysis, electric welding, high frequency heating, etc.) Here are also discussed the problems on the use of radioactive tracers and radiation techniques in science and medicine

Teaching physics at secondary as well as at middle school is based on experiments. Theory is closely interwoven with a number of demonstrations, laboratory experiments (minimum of demonstrations and experiments on each part is defined by syllabus)

The study of main themes is accompanied by laboratory work. Besides, special practical work for pupils is obligatory after studying important themes.

At Soviet schools the international system of units I.S. and C.G.S. are used but the system of I.S. is preferred. Use of some other units is possible. The system I.S. and its principles are studied in class IX.

At present serious research work on the further development of the contents of the course of physics and methods of teaching is being carried out in the USSR. Great attention is paid to the growth of the cognition of pupils. Leading pedagogical and scientific institutions and prominent scientists working in various fields of science participate in this work.

Young folks corner

Scientists You Should Know

Professor P. Maheshwari

IN our last issue we had occasion to felicitate Prof. Maheshwari on being elected Fellow of the Royal Society of London. This distinction is indeed a rare and unique one. In electing him, the Royal Society has fittingly recognised his work in botany and has paid a tribute to a man who has dedicated his life to the science he loves.

Professor Maheshwari has reached this position by dint of hard work, perseverence and meticulous attention to perfection in whatever work he undertakes. Many of his students will tell you how early in the day he comes to the laboratory and how long he works there. His life is really a source of inspiration to any young aspiring botanist.

Profesosr Maheshwari was born at Jaipur on November 9, 1904. His father Sri Bijay Lal gave him the best education. He graduated from the Ewing Christian College, Allahabad, where he came under the influence of late Dr. Winfield Dudgeon, an American missionary. He got his doctorate in the year 1931, working on the morphology, anatomy and embryology of some angiosperms. This was the beginning of a career which brought him international recognition. He first joined the Agra College as a Lecturer in Botany and then became the Associate Professor. He left on an European tour in 1936 and after return joined the Allahabad University for a short time and also served for a short time at the Lucknow University. In November 1939, he joined the University of Dacca (then in undivided Bengal). He again left on a tour of Europe and the U.S.A. in 1945 for a couple of years. On return he was promoted as Professor and Dean of the Faculty of Science. He started the post-graduate classes in botany in the year 1947 in the Dacca University. In 1949, he was invited to join the newly started University of Delhi as the Professor and Head of the Department of Botany. This position he has held very creditably up to this day.

Professor Maheshwari has travelled very widely. In 1936–37, he worked at the University of Kiel and visited several universities in the continent and in England. One of the persons who inspired him most was Prof. Karl Schnarf of the University of Vienna (Austria). During his second visit abroad in 1945, he devoted most of his time at the Harvard University where he completed the manuscript of his book *An Introduction to the Embryology of Angiosperms,* which is being used by many students in the universities. This book has since been reprinted twice and also translated into Russian. It was during a visit to the Smith College, Northampton, Mass., that the late Professor A.F. Blakeslee aroused his interest in experimental embryology. His interest in this field has lead to the establishment of a section of experimental morphology and embryology at the University of Delhi. Another book, *Recent Advance in the Embryology of Angiosperms* edited by him has also been published.

PROF. P. MAHESHWARI FRS

His next three visits abroad were to attend the International Botanical Congresses at Stockholm, Paris and Montreal in 1950, 1954 and 1959 respectively. At the invitation of UNESCO, he visited Indonesia in 1952 and Egypt in 1954. In 1958, he paid a short visit to the U.S S.R as a member of a scientific delegation sponsored by the Government of India. In 1959, he was a visiting Professor at the University of Illinois, where he delivered a course of lectures. Earlier in 1956, he paid a short visit to the U.S A. as a member of the study group for studying the courses in General Education in American Universities. This project was jointly sponsored by the Government of India and the Ford Foundation for introducing the teaching of this subject in Indian universities.

In 1961, he visited on an invitation several West German universities and also attended the annual session of the German Botanical Society at Halle. In 1964, he again visited the U.S.A. and took an opportunity to spend a few days at the headquarters of Biological Sciences Curriculum Study, Boulder, Colorado, where some text-books in biology are being prepared for American schools. Last May, he visited the U.S.S.R. and was there for a month. In September this year, he will be visiting Australia and spending six weeks there.

He is a Fellow of the Indian Academy of Sciences, the National Institute of Sciences of India and the Indian Botanical Society, and a Corresponding Member of the American Botanical Society and Honorary Foreign Fellow of the American Academy of Arts and Sciences. He has also been made Foreign Member of the Kaiserlich Deutsche Akademie der Naturforscher, Halle. In 1959, he received the honorary doctorate of the McGill University, Montreal. In recognition of his contributions to Botany, he was awarded the Birbal Sahni Medal of the Indian Botanical Society for the year 1959 and the Sunder Lal Hora Medal of the National Institute of Sciences of India. To commemorate his 60th birthday the Indian Botanical Society published a special volume with articles from prominent botanists all over the world.

He has served as President of the Indian Botanical Society in 1951 and he has also presided at the Botanical Section of the Indian Science Congress. He has held the office of the Vice-President of International Botanical Congress at Stockholm and he has been the President of Embryology Section of the International Botanical Congress. He has also been the President of the National Academy of Sciences in India.

Professor Maheshwari has started a school of plant morphology and experimental embryology in Delhi University. He has built up a fine team of workers who have already made a large contribution to this field. His Department of Botany has now been established as an Advance Centre for Research in Plant Embryology.

He was largely instrumental in establishing the Internationl Society of Plant Morphologists of which he was elected the first President. The society is mainly concerned with the dissemination of knowledge in the fields of plant morphology, anatomy and embryology. The society publishes a journal *Phytomorphology* which is one of the foremost scientific journals in India and has a wide circulation.

During recent years, he has been taking a keen interest in the improvement of science education, particularly, biology in the

schools. He has accepted the Chairmanship of the Biology Textbook Panel established by the National Council of Educational Research and Training for the production of textbook, laboratory manual and teachers' guide in the science of biology. The panel has made very good progress under his able guidance and it has already published two sections of the book while the third will be published in August. This textbook *Biology—A Textbook for Higher Secondary Schools* is currently in use in all the schools under the Central Board of Secondary Education and all the central schools run by the Ministry of Education all over India. He has also been associated with the framing of the syllabi for science subjects of the Regional Colleges of Education established by the National Council of Educational Research and Training.

Professor Maheshwari is an excellent teacher, a good technician, a persevering research worker and a meticulous organizer. He can accept nothing but the very best and does not tolerate anything below standard. At the same time he is ready to help anyone who takes an interest in the advancement of biology particularly botany at all levels. He is also keen on maintaining contact with all Indians who are working in the field of botany.

His mother lived with him to a ripe old age and was with him till the year 1961. He married Smt. Shanti in 1923 and they have three sons and three daughters. It is a very unique feature that botany runs in the family and some of his children have already made significant contributions to that science.

S. DORAISWAMI

The Royal Society of London

THE Royal Society is a very old association It was formed by some people to whom the experimental method of research was more important than the blind following of dogmas At the beginning of the 17th century, a number of persons with similar views began to meet weekly in various places to discuss natural philosophy and to carry out experiments. This group of persons called themselves the Invisible College and on November 28, 1660, it was decided by them to establish the college with a formal constitution. King Charles II encouraged this venture and it became known as the Royal Society. It was given a Royal Charter of Incorporation in 1662 and the King became the Founder and Patron of the Society He gave the Society a mace and a folio volume to bear signatures of the Royal Patrons and the Fellows. These two are still the treasured possession of the Society.

Natural science made rapid progress in the second half of the 17th century and much of this was due to the Fellows of the Royal Society. Eminent pioneers like Robert Boyle, Robert Hooke and Isaac Newton belonged to this group. The Royal Society is located at Burlington House, Piccadilly, London since 1857. Besides holding meetings, the Society also directed the voyages of Captain James Cook. A distinguished botanist Sir Joseph Banks accompanied Cook on these voyages.

Many prominent men of science were Fellows of the Society. A few of these were Henry Cavendish, James Watt, Herschel, Humphrey Davy, John Dalton, Michael Faraday, Clark Maxwell, Lord Kelvin, J. J. Thomson, Ernest Rutherford, Charles Darwin and Joseph Lister.

Ramanujam, a great mathematician, was the first Indian to be elected Fellow of the Royal Society. Later scientists of this country to be so elected are Dr. C. V. Raman (Physics); Sir J. C. Bose (Botany); Prof. M. N. Saha (Physics); Prof. Birbal Sahni (Botany); Dr. H. J. Bhabha (Physics); Prof. S. Chandrasekhar (Physics); Prof. P. C. Mahalanobis (Statistics); Dr. S. S. Bhatnagar (Chemistry); Prof. K S. Krishnan (Physics); Prof. S. K. Mitra (Physics), Prof. T R. Seshadri (Chemistry); and now Prof. P. Maheshwari (Botany).

When the Society was started, the number of Fellows remained between 100 and 200, but by 1847 it increased to 764. Strict rules of qualification were introduced and the number of Fellows elected each year was only 15, a number which has since been raised to 25

There are three main categories of Fellowships. The first is that of Royal Fellows, which at present comprises Queen Elizabeth II, the Queen Mother and three Royal dukes including the Duke of Edinburgh. Queen Elizabeth II is the Patron now. The second category is that of foreign members who number 65 distinguished scientists from many lands. The third category that of Fellows who must be citizens of the British Commonwealth, constitutes the main element of the Fellowship. There are now 597 of these, of whom about 72 reside overseas. An important activity of the Royal Society is that of holding

meetings and publication of research work. At the weekly meetings, original papers are read, special discussions, meetings and lectures are also held. Several lectures are given as a result of endowments. The oldest of these are the Croonian and the Bakerian which originated in 1701 and 1775 respectively. The most recent one is in the name of Leeuwenhoek, the famous Dutch naturalist who first observed and described bacteria and who communicated many of his observations to the Royal Society. One of the earliest publications started in 1665 by the Society was *Philosophical Transactions of the Royal Society*. In 1832 the *Proceedings* began. The Society also publishes a Year Book which contains much useful information, a volume on past Fellows which is a valuable contribution to the history of science and a journal, *Notes and Records of the Royal Society*. The Library of the Society contains 150,000 volumes. The Royal Society has funds derived from donations and bequests for the support of scientific research.

In England the Society administers parliamentary grants for the assistance of research, scientific publications and international research and congresses. It took a leading part in establishing Britain's National Physical Laboratory and even now it controls its scientific policy. The Fellows of the Society assist the British Government by tendering advice on scientific matters. They are appointed to about 100 governing bodies and committees of leading universities, colleges, schools and research institutes. In such ways the Royal Society without any research institute of its own does very much through its Fellows to influence the course of development of science in the United Kingdom.

The co-operation between scientists of different nations is one of the noteworthy developments in the international field. It holds promise of more friendly relations with them. Such co-operation is necessary for the development of more fields of science as meteorology, geophysics and oceanography. This is exemplified by the International Geophysical Year, the International Year of the Quiet Sun, the International Indian Ocean Expedition, etc. In all these enterprises the Royal Society takes a leading part.

The full title of the Society is, 'The Royal Society of London for the Promotion of Natural Knowledge.' The title describes one of its important characteristics. It is concerned only with natural sciences and not like many national academies with the humanities. A second important character of the Society is that the Royal Society is a private and independent scientific society. The society owes its influence to its prestige. It has achieved, and maintains this prestige by its insistence on upholding the highest scientific merit not only by its awards in choosing a recipient of its research grants but especially in the selection of those persons that it deems worthy of election to the Fellowship.

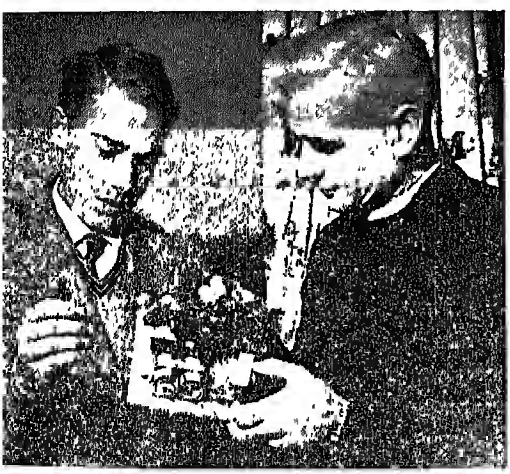
Science notes

YOUNG SCIENTISTS SHOW THEIR WORK

AN electrical resistance thermometer, capable of registering infinitesmal changes of temperature, won two important awards recently for 17-year-old Australian schoolboy, David Kerr. David, a pupil at St Edmund's College, Canberra, designed and built the thermometer himself.

He entered it in an annual exhibition held by the Science School Teachers' Association of the Australian Capital Territory. It won the two major awards for scientific instruments based on original investigation.

David's thermometer, a small but complex instrument which took him 18 months to think out and three weeks to build, faced some strong competition in the exhibition which was open to all secondary school children in Canberra.



avid Kerr and the electrical resistance thermometer he built

David Kerr's thermometer has many purposes but as an experiment for the exhibition he put it to only one use—testing the efficiency of electric light bulbs.

The results were interesting to his fellow scientists, though rather depressing for buyers of electric light bulbs. Of the six brands of bulbs which he tested he found that some were only 23 per cent efficient. Even the best were no more than 33.8 per cent efficient as givers of light.

David, who hopes to take an electrical engineering course when he goes to university next year, said his experiment had given him one useful piece of practical knowledge. He now knows which will be the most economical brand of light bulbs to buy when he has to stay up late studying.

By Courtesy: Australian High Commission, New Delhi.

LOWEST TEMPERATURE ON EARTH

Scientists at Oxford, believe that they have achieved the lowest temperature on earth—within one millionth of one degree above absolute zero. Absolute zero, at minus 273.13°C., is theoretically unobtainable according to the laws of physics.

The temperature was reached with equipment at the Clarendon Laboratory, Oxford, where a special laboratory for studying very low temperature phenomena has just been inaugurated.

The experiments now being carried out are aimed at the study of properties of substances for which the transition into the state of perfect molecular order postulated by the laws of thermodynamics occurs at those extremely low temperatures.

In the field of superconducting materials it is thought possible that electrical energy may be stored for subsequent release

By Courtesy: British Information Service

NEW TYPE OF GLASS DARKENS AND BRIGHTENS AMID CHANGING LIGHT CONDITIONS

A new kind of glass that darkens when light shines on it and clears when the light is removed, has been developed in the United States.

Still only in experimental use, the glass may be suitable for windows and walls, for sun glasses and, possibly, for auto-windshields which would automatically adjust to lighting conditions.

Although the principle of photochromism—a change in colour through exposure to light—has long been known, scientists say this is the first time that glass has been developed with the property of changing back to its original clear shade and repeating the darkening—clearing cycle indefinitely.

This ability is due to tiny, light-sensitive crystals of silver halide—a compound of silver and either chlorine, fluorine, bromine or iodine.

When the light strikes the crystals, the compound breaks into silver and the other element, and darkening occurs. Some samples become so dark that only one per cent of the light comes through. As the light intensity lessens, the silver and the other atoms rejoin, clearing the glass. The crystals are so tiny that they do not affect the glass's transparency.

Silver halide crystals are also used in emulsions for photographic film, but there the process is irreversible.

Scientists of the Corning Glass Works, Corning, New York, who developed the glass, say speed and intensity of the darkening and brightening can be controlled from a fraction of a second to several minutes by varying the proportion of silver to the other element during manufacture.

INTERPLANETARY MONITORING PLATFORM DISCOVERS IMPORTANT SPACE PHENOMENA

The Interplanetary Monitoring Platform (IMP) launched into an unusual orbit by the U. S. National Aeronautics and Space Administration from Cape Kennedy on November 26, 1963, has made so many important discoveries about the solar system that U.S. experts consider it one of the most successful space research ventures todate.

The 138-pound (62-kilogram) IMP, originally known as the Explorer-18 satellite, revolves around the earth once about every four days in the most stretched-out orbit yet achieved. During each orbit, the satellite comes within 120 miles (192 kilometers) of the earth and then veers 122,800 miles (196, 480 kilometres) away from earth, about halfway to the moon.

During these journeys, eight instruments aboard give scientists their first extended opportunity to survey the vast stretches of space between the sun and the planets.

Through information furnished from the satellite, U.S. scientists have determined that the moon has magnetic effect that extends in the shape of a giant teardrop at least 68,000 miles (108,800 kilometres) into space away from the sun. However, the discovery does not necessarily confirm a theory that the moon has its own magnetic field. The magnetic effect could result from tiny particles ejected by the sun as 'solar wind' becoming trapped by electrified particles on the moon

The satellite also discovered a huge radiation zone 50,000 miles (80,000 kilometres) above the earth, beyond the Van Allen radiation belts, and has confirmed that the collision of solar wind with this zone sets up a shock wave which envelops the earth as it moves through space

From SCIENCE NEWS, *USIS.*

A NEW SYSTEM WILL ENSURE CHEAP ELECTRICITY

The announcement that the second generation of British nuclear power stations will be based on the advanced gas-cooled reactor (AGR) system is evidence of the remarkable achievement of British engineers and scientists in this field.

This British-developed system has proved itself to be the cheapest, in terms of generating cost, compared to other competitive reactor systems, mainly from the United States. And for the first time, the cost of electricity from nuclear energy has been brought below that of power from conventional stations.

Dungeness B, on England's south-east coast—the first station to use the new system—is due to start operating in 1970. It will have two reactors of the AGR type, each producing about 600 megawatts of electric power. The cost of a unit of electricity from the station works out to about 0.45 pence (2¼ paise)—and perhaps will be even lower.

The break-even figure which the nuclear power industry has had in its sights ever since it began expanding in Britain is roughly 0.5 pence a unit. To get below this with the first commercial station of its kind and to undercut the most modern coal-fired stations coming into service at the same time is an outstanding technical success.

A development of the Calder Hall or Magnox type of reactor, the AGR is also graphite-moderated and gas-cooled. Its fuel, however, is uranium enriched slightly with the fissile isotope U235 instead of natural uranium, and it is in the form of uranium oxide pellets instead of metal.

AGR fuel is canned in stainless steel instead of the alloy of magnesium that gives the Magnox system its name. These improvements mean that the reactor can work at much higher temperatures and pressures, thus increasing its efficiency at steam-raising. In fact, steam from the AGR matches up to the most modern turbines and can be used to drive the biggest generating sets existing or envisaged.

But its potential is even greater. It is possible that an AGR could produce gas hot enough to be used in another power-producing system called MHD, though a great deal of research has yet to be done on this. MHD employs a stream of hot gas flowing at high speed through a magnetic field. The idea could be used in a completely closed cycle in which the gas goes round and round, to re-heat the gas on its way through a reactor

There may also be possibilities in using the AGR system for making fresh water from sea water.

Half of the experimental fuel channels used in the reactor filled with prototype commercial AGR type fuel of the kind that will be used in large power stations, some of this operating at a can temperature of 750 C. In addition, two channels contain fuel enriched with plutonium instead of uranium to explore the possibility of burning this fuel, which is made automatically in nuclear power stations as a result of fission. If the AGR can use such fuel, the efficiency of nuclear energy processes will be further increased.

Detailed studies made by the Atomic Energy Authority have shown that the AGR's containment building is unnecessary, and it is no longer operated as a permanently sealed building.

By Courtesy; British Information Service

WORLD'S LARGEST RADIO TELESCOPE

For a number of years now there have been plans for the construction of a very large radio telescope in order to extend research into the Milky Way system, to other star systems and to the investigation of the structure of the universe by means of what are called radio sources. The design of this radio telescope has now been completed in broad outline and consultations have also taken place between the Belgian and Netherlands Governments. The telescope will be installed in the province of Drenthe in the Nehterlands and will be larger than any other telescope in existence. It will have a resolving power of about six-tenths of a minute of arc.

For the investigation of radio sources such a great resolving power is a prime essential. Radio sources are star systems which emit particularly strong radiation in the region of radio waves and which as a result can be observed at distance much greater than the greatest distances which can be bridged by optical telescopes. This new leap into space takes us to particularly interesting parts of the universe where one may hope to measure the curvature of space. Moreover, the radiation from these most distant sources will have taken so long to reach us that it may tell us something about the remote past of the universe, specifically about a period in which the latter probably differed most considerably from its present state.

However, the radio sources are not only of interest as beacons for measuring the structure and the evolution of the universe; they are of equally great importance because of the remarkable, as yet completely unexplained processes which take place in these sources. For, in them, explosions occur which are many million times more powerful than those of the supernovae, in which whole stars exploded. In the radio sources star-like objects must have formed which contain many million times more mass than the sun, 'super stars', which are apparently unstable and which through their explosion have furnished the unprecedently great quantities of energy which are radiated by the radio sources. The investigation of these entirely new phenomena is now one of the most fascinating aspects of physics and astronomy. To be able to perform this kind of research properly, one requires a radio telescope with a diameter of several kilometres, instead of the 25-metre cross section of the Dwingeloo reflector. The object of the Belgian-Dutch project is to build a telescope of that size. Of course, one cannot build a complete movable

metal reflector a kilometre in cross section, but one can imitate such a reflector by placing a number of Dwingeloo telescopes side by side and combining the signals received by these various reflectors in such a way that this row of reflectors gives the same information as a continuous reflector with a diametre equal to the total length of the row of separate reflectors. The large radio telescope which is now to be built in Dwingeloo will consist of a row, about 1½ kilometres long, of 10 telescopes with a cross section of 25 metres. In this way it will be possible to achieve a resolving power of about six-tenths of a minute of arc at a wavelength of 21 cm, for which the telescope will be initially designed.

The plan for this giant telescope has passed through a period of considerable evolution in recent years. There were two reasons for this: firstly, because during the design stage all kinds of technical difficulties came to light which were not to be seen in the first approach, and secondly, because in the intervening period discoveries were made elsewhere in the world which made it desirable to adapt the design to new fields of research. In particular, in the last eighteen months the sensational discoveries have been made of the above-mentioned 'super stars' and 'quasi-stellar' radio sources.

In the original design the telescope was planned in the form of a cross. The advantage of such a shape is that all information that is required for a complete representation of the part of the heavens to be observed is obtained at the same time. A disadvantage is that in such a case about one hundred reflectors would be required to get a resolving power of one minute. The technical problem of causing the signals coming from these hundred reflectors to interfere with each other with sufficient accuracy is so complicated that it would take longer to build such an instrument than seemed justified in view of the speed at which science is developing. Exactly the same data can also be obtained by arranging the reflectors in a row running east-west and extending the observations of the part of the sky to be examined from the time that it rises in the east until it sinks in the west. As a result of the earth's rotation, this row will successively adopt various positions in respect of the sky and in the course of half a day will collect as much information as could be given by the 'cross' at one moment.

This simplification can be further extended for instance by replacing a row of evenly and closely spaced reflectors by a row of reflectors further apart and adding to the latter a reflector which can be moved over a distance of a few hundred metres in an east-west direction. This mobile reflector must then be installed at different places in the successive nights to fill the gaps between the others. The radio telescope which is now to be built in Dwingeloo will be of this form.

Courtesy: Higher Education & Research in the Netherlands—Vol. VIII, No. 4—1964.

New trends in science education

Summer Institute Programmes

SUMMER INSTITUTES: INAUGURAL ADDRESS

P. L. Bhatnagar

Indian Institute of Science, Bangalore

IT is well known that mathematics is a creative activity of mind of the highest order and an unparalleled power in application. As regards the latter aspect it will suffice to mention some of the outstanding developments in other branches of knowledge which would not have been possible without the use of some of the profound theories in mathematics. Could physical sciences have the quantum theory, theory of relativity, plasma physics, particle physics, if the mathematical knowledge which forms the basis of these subjects did not exist? Could modern engineering and technology attain the maturity which was essential for liberating man from the earth and for giving him hope to conquer space? Could social sciences like econometrics, operational research and psychology play the part which they are playing today for the benefit of society? And it is not surprising that mathematics has such a vast and varied field of action if we understand its basic nature and how it operates. Mathematics is a way of thinking and the mathematical education aims at disciplining the mind in that way of thinking. To understand this statement let us cursorily look at how mathematics works. One first decides what he takes as granted and then he does not worry himself about proving the validity of these axioms except ascertaining that they are not contradictory to each other and that none of them is superfluous, e.g., no one of these axioms can be deducted from the rest of the axioms. Next, he sets for himself certain rules for working. He then tries to draw inferences as general as possible. The outcome is a theorem or a set of theorems. Thus mathematics is a sort of game of skill played under prescribed conditions in a prescribed manner. The merit of the achievement can only be judged by the degree of its contribution to the development of the subject. If the contribution becomes an inevitable link, small or large, without which the chain of the future development of the subject cannot proceed, it is undoubtedly an achievement of the highest order.

Does the mathematical education in our country prepare people who are capable of producing such links in the development of the subject? If not, why not? Looking into the vast literature that is published every year, there is hardly a spark or two occasionaly. Most of the published research papers have no purpose, some are trivial and very few at the most reaching the level of second class research judged from the international standards. This state of affairs exists in

Inaugural speech at the opening ceremony of the Summer Institute in Mathematics held at the University of Madras, Extension Centre, Madurai, April, 1965.

spite of our professing all the time that the fundamental aim of mathematical education is to train the minds of the students in precise thinking and to excite their imagination for tackling new problems. I do not feel shy to say that the majority of the students that come out of the universities even with first class degrees at the Master's level has very defective understanding of the subject, lacks in imagination and originality and worst of all, has no real liking for the subject. Their concern with the subject is more or less on the basis of source of employment rather than 'knowledge for knowledge's sake.'

Is it not a matter of common experience that most of the students are able to establish in examinations cumbersome books and articles and write solutions of some of the complicated questions whose solutions they have known previously, but are unable to tackle unknown questions however simple they may be? Perhaps here lies the clue for the answer to the question which I have just now posed. First, let me talk about the people of my own community, namely, the teachers. I do not think there is any dearth of conscientious teachers who really want to discharge their duties with honesty. However, a vicious circle has developed round our educational institutions. The examination system of to-day amounts to the examination of the teaching ability of a teacher. A good percentage of passes makes him an efficient teacher and *vice versa*. In most cases, the teacher has to accept students on certain other considerations than their ability to pursue the course. Clearly, under these circumstances, to preserve himself, I presume perhaps most unwillingly, he resorts to unacademical practices both in teaching and examination For example, teachers concentrate while teaching on the portions which are important from the point of view of examination, provide solutions of all the problems which are usually asked in the question papers, do not forget to discuss thoroughly last few years' papers, for they know that there is a 90 per cent chance of repetition of questions from them, and finally, if 10 per cent chance has its upper hand, they have no hesitation in throwing the blame for disaster on the shoulders of the poor examiner for, by doing so they may be able to extract some sort of concession for the students from the university. The students are a clever class they not only know all these things but also understand fully the implications of these things. This situation takes away all the initiative from the students. They forget that learning of the subject is their own affair and that a teacher's job is only to show them the path. I need not further elaborate this stinking episode and close it by saying that most of the indiscipline in which the present day student community has distinguished itself stems from this situation. Moreover, with the short cuts available to them for getting success at the examinations, they have enough leisure to misuse their youthful energy and adventurous spirit in channels other than academical. If, on the other hand, the method of instruction would have been lively, if there would have been more intimate intellectual contact between the teacher and the taught and if there would have been a burning desire in the hearts of the pupils for acquiring knowledge, the state of affairs would have been different. Among this hoard of disinterested students, every now and then we come across a few who have acquired brilliance of mind. If we study their case histories, it will be found that these people are those who have developed a certain amount of idealism, who are not aiming at achieving only the practical goal, namely, that of passing the examinations, and who

have consequently burnt the midnight lamps in the hope of gaining some knowledge. They are the persons who have struggled through most of the problems by their own efforts and in doing so they have acquired such an intimate familiarity with the subject that when asked to reach a destination, however remote it may be, they will be able at once to choose their path with confidence which will lead them to the goal The ill-conceived methods of teaching and the vagaries of examination will not be able to demoralize them.

As a school-boy Newton had constructed a water-clock, a wind-mill and a carriage moved by a person who sat in it and at the age of twenty-three, he had made his most profound contribution to mathematics, namely, the concept of fluxions, the fore-runner of calculus. At the age of seventeen, in recognition of his brilliant work, Lagrange was made Professor of Mathematics at the Royal Military Academy at Turin and at the age of nineteen he had given the general method of solution of isoperimetric problems, known now as the calculus of variation. Inspite of all the handicaps of being born of extremely poor parents, Laplace at the age of eighteen had sent a paper on mechanics along with other recommendatory letters to get support of D'Alembert for some job, which impressed D'Alembert so much that he wrote back to him the following reply and obtained for him a Professorship in mathematics at the Ecole Militaire at Paris: 'You need no introduction; you have recommended yourself; my support is your due!' In the following few years his brilliant work in mechanics and astronomy earned him the title of 'Newton of France' Hamilton, at the age of thirteen, had learnt as many languages as he had lived years, at the age of eighteen he had corrected a mistake in the work of Laplace, at the age of twenty-two, while he was still an undergraduate, he was appointed to the Chair of Astronomy and soon after that he wrote the principle of least action which goes in his name. It is well known that Abel died at the age of twenty-seven from tuberculosis induced by poverty and Galois died at the age of twenty-one of a pistol shot received in a meaningless duel, yet during these short spans of life they produced that work which has left a permanent stamp on mathematics. Similarly, Ramanujam worked under all hardships that one can imagine and breathed his last at the age of thirty-three, yet his contribution to theory of numbers and the theory of elliptic and modular functions was so great that Prof. Hardy, his friend, philosopher and guide, paid him the following tribute: 'His (Ramanujam's) work has one gift which nobody can deny—profound and invincible originality. On this side most certainly, I have never met his equal and I can only compare him with Euler and Jacobi. European mathematicians will take fifty years to decipher what is contained in his note-books.'

It is clear that everybody cannot be an Euler or a Gauss or a Ramanujam, but it is certain that with a sincere effort everybody can acquire a deep understanding of the subject. Let us remember the English saying that, 'the battle of Waterloo was won on the fields of Eton' meaning thereby that the early years of life, to a great extent, determine the course of future life. This is more true in case of mathematicians. History of mathematics shows that early maturity and sustained productivity are the rule, not the exception, for the greatest mathematicians. Youthful mind with its profound vigour and spirit of adventure is surely more suited to conceive revolutionary ideas though it may take time to work them out. For

example, Gauss spent about fifty years of his life in developing some of the inspirations that came to him before he was twenty-one. However, one thing is certain that brilliant flashes of thought do not come of their own or at the ordaining of destiny; they come as a result of continual involvement in the subject with devotion.

The moral of this discussion is evident. There is no short cut to learning though there may be short cut to passing the examinations; you cannot have the exhilarating joy of diving deep into the ocean of knowledge in search of the pearls by simply sitting at the sea-shore and counting few waves breaking there; by reading the composition of some person a poet cannot launch himself into the same sort of ecstasy in which he finds himself after completing his own; those who have not created cannot understand the sense of self-fulfilment which a creative scholar or a creative artist experiences. It was not without reason that in ancient India, the *gurus* used to live with their disciples far away from the pomp and show of the capitals. It was not without purpose that even the mighty kings could not interfere with the programme of the *gurus* and regarded it a real privilege to sit in front of them. Did the teacher and the taught not live in perfect intellectual communion with each other and carried their pursuit of knowledge without any distraction? Did the kings not get independent and frank advice from their *gurus* which averted many a crisis? I am not suggesting for a moment that we should put the wheel of time back. I know it is neither feasible nor advisable. However, I am fully confident that with honest efforts and by fostering those ancient ideals, we can make our universities and colleges real temples of learning. Let the society learn to respect its teachers and let the teachers catch the true spirit of a teacher by regarding teaching as a mission and not a profession. Existence of such an atmosphere of understanding is a pre-requisite before we can reform the present state of education and research in our country.

Summer Institute for Teacher Educators

A Participant's Reaction

KNOWLEDGE, particularly scientific knowledge is growing by leaps and bounds. Learners and educators in the field of science are finding it hard to keep pace with the ever increasing volume of new ideas and the evolution of new concepts incorporating the old in them. The only remedy could be that one should always be a student. This is most essential for teachers including the university professors. It is this realisation that caused the holding of Summer Institutes, since a few years in the U.S.A., in order to provide short-term refresher courses in science concepts and methods of teaching to teachers of science in secondary schools. For the past three years, Summer Institutes in science are being organised jointly by the U.G.C. and the N.C.E.R.T. in collaboration with the United States Aid for International Development. The number of centres is increasing every year

During the six weeks from April 26 to June 4, 1965, a Summer Institute was organised in India exclusively for teacher educators (in physics and chemistry). The venue was the Regional College of Education, Mysore. Besides being the first of its kind, this Summer Institute had certain other unique features. It had participants from all over India and these participants went through both the P.S.S.C. and the CHEM Study programmes. They also discussed some problems of teacher education in India and suggested follow-up activities for the P.S.S.C. and CHEM Study programmes in their own training colleges and practising schools. Except for the fact that all the participants were teacher educators the group was heterogeneous from more points of view than one. It consisted of 38 persons, hailing from twelve different states of India, varying in age from 26 to 56 years, holding posts from Assistant Lecturers to Professors, having food habits peculiar to each state and parts of a state, some with a master's degree in content and others with a master's degree in profession. It is no

Teacher Educators at work in the Institute

exaggeration when I say that this group became more and more homogeneous as it went through the Summer Institute programme.

Teacher Educators at work

All the participants including those from Mysore City stayed in the college hostel. They were engaged in the Institute from 9.30 A.M. to 12.30 P.M. and again from 2.30 P.M. to 5.30 P.M. each day on five days in the week with an additional programme of film shows from 6.30 P.M. to 8.00 P.M. Saturdays were used for field trips or excursions and Sundays for rest and for attending to home assignments.

It was a thrilling and memorable experience to each participant both educationally and socially. Educationally because, the method of 'Learning by Doing' was practised by them for the first time, new concepts were acquired, new devices were handled and an opportunity was provided to learn correctly many concepts which were to them hitherto vague or abstract, or merely bookish, or were wrongly acquired. Socially because, it was as if all India had met on a common platform to discuss common problems, to know, to greet, to imitate the food habits or the language of one another and to get acquainted with the two fine teachers from the U.S.A., Dr. S. Winston Cram and Dr. Charles L. Koelsche

Let me now say something about the P.S.S.C. and the CHEM Study courses. They deal with the fundamentals in physics and chemistry respectively. They avoid the study of material which should have to be unlearned in some higher grade of education, as for example, the rule of signs in measuring distances from a lens or a mirror, the long and cumbersome statements attempting to define concepts or describe instruments and apparatus, the traditional meaning of valency, oxidation-reduction and several things which are usually found in the traditional textbooks and govern the teaching based on them. The emphasis in these courses is on thinking, acquiring correct concepts through inductive and analytical reasoning and developing in the pupils a spirit of inquiry through intelligent questions, as contrasted with terminology, memorization, blind acceptance and deductive reasoning emphasized in the traditional teaching methods. Besides, there is greater emphasis on the qualitative aspect and understanding than on the quantitative aspect and precision in measurement.

Each participant in our group was supplied with the Physics text, 'The Physics Laboratory Guide' and the Chemistry text, and 'The Laboratory Mannual for Chemistry'. He/she was expected to read from the books, the experiments assigned for the next day. But sometimes clear understanding would not be possible, by a mere reading unless the apparatus or other material was on hand. Doubts and difficulties arising during the experiment were solved by the consultants or their assistants. Measurements were made, observations were recorded and graphs were drawn wherever possible and inter-

pretations made of them. Discussion of the results was taken up in the next theory class and before the next experiment was assigned. Every experiment commencing from the measurement of short-time intervals up to the determination of the mass of an electron in physics, or commencing from the observation and description of a burning candle up to the experiment on the relation between the moles of copper, moles of silver and moles of electrons involved during electrolysis was highly interesting and illustrative

Many teaching devices under the P.S.S C. and especially those in parts 1 to 3 are novel and can be improvised without much cost or difficulty. Some of these are capable of varied application. Let me illustrate with two examples.

The Stroboscope: This can measure short time intervals or high speeds. It consists of a circular disc or wood about 10 inches in diameter and half an inch in thickness with 12 slits spaced at 30 degrees round the circumferance. The slits can be covered by black tape. This disc is attached at the centre to a rectangular frame of wood $10'' \times 2'' \times \frac{1}{2}''$. There is a hole near the centre of the disc in order to keep a finger and turn it. Any rotating or vibrating object can be viewed through the slit in the wooden frame and keeping one or more slits of the disc open. By rotating the disc its speed can be adjusted so that it is equal to the speed of rotation or vibration of the object, when the object would appear to be still. The speed of the stroboscope can be measured by a stop-watch and hence the speed of rotation or vibration of the object can be known. It is possible to find the speed of rotation of an electric fan, the vibration of a bell clapper, the ripples on water in a tank or the frequency of an A.C. circuit. It was by the same principle that Fizeau measured the velocity of light by a terrestrial method. His stroboscope had 200 openings and was rotated at 54,000 revolutions per minute.

The Ripple Tank: A colourless sheet of glass 50 cm x 50 cm x 0.5 cm is fixed into a metal or wooden frame-work so as to make a leak-proof tank, the boundaries of the tank being approximately 3.0 cm high. This tank is made to rest in a horizontal position at about 50 cm above the ground, by suspending it or by supporting it from the ground Clean water is poured into the tank to a depth of about ½ cm. The depth of water is measured at the corners and uniform depth is secured by adjustment. A large white paper is kept on the ground below the tank and is held in position by weights. A powerful electric lamp suspended at about 50 cms above the tank serves as a source of light to illuminate the water in the tank. The lamp is covered on all sides, except the bottom by a dark cover, so that a shadow of the tank falls on the paper. A piece of cloth, sand or wire-gauze along the borders of the tank serves as a damper. Now the ripple tank is ready for use.

In order to generate straight waves in the tank a straight rod 30 cm long and about 2 cm in diameter may be used. To generate circular waves a thin bent wire attached to the hammer of an electric bell may be used.

Uses of the Ripple Tank in High Schools: The ripple tank can be used for a variety of purposes such as ; (i) to illustrate the concept of a wave and to demonstrate that there are things other than particles of matter that can move from one point to another point; (ii) to show that particles of water or a liquid in which waves are

generated do not move along with the wave; (iii) to demonstrate the nature of transverse waves as compared to the longitudinal waves along a stretched string or rubber, (iv) to demonstrate circular and straight wave patterns and to measure wave length, period and wave velocity; (v) to demonstrate the phenomena of (a) reflection (b) refraction and (c) disperal of waves and to serve as a means of bringing the analogy between these phenomena in ripples and similar phenomena in light. In addition to the above, the ripple tank can be used for a few more demonstrations in higher secondary schools such as: (vi) to demonstrate the phenomena of (a) diffraction (b) interference (c) effect of a difference in phase, and (vii) to illustrate the formation of nodal lines.

Though the CHEM Study programme had much in common with the P.S.S.C., it had its unique features. Here each participant had to rely on himself and most of us did so in almost all the experiments. The five experiments in Part I on 'Observation, interpretation, precision and measurement' consisted of activities such as observation of a burning candle, warming up a few solids, heat effects on wax, etc. These serve to lay the foundations of chemistry, through such concepts as melting point, heat of solidification, heat of combustion, physical change and chemical change. In Parts II and III the student is introduced to the study of quantitative chemistry through reactions involving the concepts mole, gram molecular volume, molarity, pressure of a gas, aqueous tension, etc. At the end of each experiment there are challenging questions and a few additional assignments for the above average pupils. It was a real wonder to us when we found by experiment and calculation the enormous difference between the heat of solidification and the heat of combustion of a candle or when we, for the first time, observed the fine crystals of silver deposited on a copper wire dipped in a solution of silver nitrate. It was more surprising to find, that the weight of silver nitrate obtained from the above crystals of silver was more than the weight of silver nitrate which gave the silver deposit. Here there was something to think and reason out about what could take place in chemical actions as if contradicting the laws of chemistry. Other examples for wonder and the joy of discovery were when we found that H_2= H_1 plus H_3 where H_1 is the heat of reaction of NaOH (solid) with water, H_2 is the heat of reaction of NaOH (solid) with HCl (aq), and H_3 is the heat of reaction of NaOH (aq) with HCl (aq); and when we observed the effect of concentration and of temperature on chemical reactions—things which had remained merely bookish to most of us.

Lectures on the modern concept of valency in terms of the number of electrons that an atom of an element could give or take (which again depends upon the number of electrons in the outermost shell of an atom), on the concept of oxidation as a consequence of loss of electrons, on the formation of compounds through different kinds of chemical bonding, on the different kinds of orbitals containing electrons at different energy levels surrounding the nucleus of an atom and the representation of chemical reactions in terms of ionic or net equations were eye openers to many of us regarding the latest trends in the content and methods of teaching chemistry in secondary schools.

Let me now say something about what we learnt in the institute regarding methods of teaching:

1. We found that learning by doing is a sound principle and yields very good results

if practised, practice preceding theory with scope for individual work at one's own pace and extra assignments for the more abled.

2. We realised the necessity for a pupil's guide book for science laboratory work; the guide book should be based on the textbook and must contain challenging questions and assignments with no room for mechanical work or memorisation but thinking being demanded at all steps.

3. In order to create and sustain interest and attract attention, the experiments should be novel and capable of simplifying and concretising the complex or the abstract concept. The ripple tank, the inertial balance, the pendulum of sand are some examples.

4. Whenever relationships could be expressed quantitatively, graphs should be drawn. Many a time a relationship is discovered through the graph. Physical and chemical relationships can serve as practical examples which could be used while teaching the critical mathematics.

5. We realised that tests must be so constructed as to test understanding and ability for application and not for testing memory.

6. Films are essential accessories to teaching. They serve to concretise the abstract ideas, to clarify doubts, to supplement learning and to introduce expert teachers and their methods of teaching to many for whom those teachers are inaccessible.

Prof. M. D. Devadason insisted that each participant should draw a follow-up programme of activities to be implemented after his return to his college.

K. RAMA RAO

Some Facts About Summer Institutes

ADDRESSING the participants at the closing function of the Summer Institute in Biology, Delhi University, Dr. D. S. Kothari made reference to some interesting features of the programme. Some of these are given here.

Different events have different periods of doubling in history. Thus national biographies have a doubling period of 100 years, population has one of 50 years, top scientists and gross national products, 20 years; science as a whole, 15 years; scientific knowledge in some branches, 10 years; some special branches of science, 3-5 years, but the Summer Institutes in India have the shortest doubling period, viz., a few months. The uumber of Institutes held in the past few years and proposed to be held in future are:

	No. of Institutes	No of participants
1963	4	160
1964	44 16	2200
1965	94 28	4700
1966	130 50	—
1969	280 180	14000

(The figures in the brackets refer to institutes for college teachers.)

The total number of teachers who would have been trained by 1969 would be 51,000. This will be $\frac{1}{4}$ of the total science staff of secondary schools and colleges. In ten years every one will get a chance.

Summer Institute Programme is an illustration of the co-operative activity of a number of organisations interested in the advance of science. The participation of American scientists had an effect of triggering the Indian effort.

News and notes

A UNESCO PROJECT

UNESCO Technical Assistance Programme

AFTER a study of the recommendation of the UNESCO Planning Mission it was decided that the programme of Science Education as contained in the report should be tried out as an Experimental Project in some selected schools in Delhi. In consultation with the Delhi Directorate of Education 15 schools have been selected where it is proposed to start the teaching of sciences as physics and biology from Class VI and chemistry in Class VII and mathematics in VI and IX. With the help of the UNESCO experts the Department has developed syllabi in these subjects for the middle stages. A continuous syllabus for the secondary stage has also been prepared. The officers of the Department and experts are busy in preparing teaching material for printing and in formulating their programme for the teachers of these experimental schools.

The teachers of the selected schools would be oriented first and the progress of the experiment would be closely watched and group discussions held quite often with the teachers.

The following experts of the UNESCO Mission are working in this Department in close collaboration with the officers.

Dr. G. G. Maslova	Mathematics
Dr. A. V. Brioukhanov	Physics
Dr. V. A. Gluoshenkov	Chemistry
Dr. O. N. Sazonova	Biology
Dr. I. D. Zverev	Teacher Education
Mr. V. N. Smirnov	Workshop
Mr. N. S. Stepanov	Interpreter

SCIENCE TALENT SEARCH EXAMINATION 1965

The examination for selecting talented students under the scheme was held on January 3, 1965. The written examination consisted of an aptitude test and an essay paper. The contestants had to submit a project report. These were evaluated. On the basis of the marks obtained, 1152 students were called for interview at 5 different centres in the country. Finally 325 candidates were selected for the award of scholarships. The scholarships will be tenable only if the awardees pursue science course in the colleges. The statement below gives some figures regarding the number of candidates who appeared, number interviewed and the number who were finally awarded the scholarship according to the States to which they belong. Besides these awards, 190 were awarded Certificates of Merit.

State/Territory	*No. of candidates who appeared*	*No. of candidates called for interview*	*No. of candidates selected for the award*
Andhra Pradesh	545	50	4
Assam	42	9	7
Bihar	180	25	13
Gujarat	94	13	—
Jammu & Kashmir	17	—	—
Kerala	61	11	1
Madhya Pradesh	993	76	2

Maharashtra	237	136	36
Madras	460	99	13
Mysore	184	90	23
Orissa	38	14	6
Punjab	452	60	11
Rajasthan	313	29	5
Uttar Pradesh	1677	95	27
West Bengal	394	150	77
Delhi	586	262	97
Himachal Pradesh	15	—	—
Manipur	11	—	3
Tripura	28	5	2
Goa	6	5	1
Pondicherry	59	20	—
Andaman & Nicobar Islands	3	—	—
Total	6395	1152	325

Shri Vivek Caesar Monteiro of Goa, who stood first among the awardees of 1965.

Kumari Tanima Karkum of Uttar Pradesh, who stood first among the girl candidates and was fifth in rank.

SUMMER SCHOOLS FOR SCIENCE TALENT SEARCH SCHOLARS

In order to nurture the scientific talent identified through the Science Talent Search Scheme, it was considered necessary that a number of Summer Schools should be organized all over the country in order to provide a suitable scientific atmosphere to the awardees so that they may utilize their creative abilities in a fruitful way. Based on this philosophy, five Summer Schools were organized in the month of May 1965 at Delhi, Bhubaneswar, Poona, Meerut and Hyderabad. These schools were run for a month and an effort was made to provide stimulating environment to the participants so that they may develop their basic potentialities to a sufficient extent. The entire programme consisted of lectures on modern development in basic sciences, workshop practice, laboratory experiments, individual project work, individual and group discussions, excursions to places of scientific interest, film shows and lectures from eminent scientists and educationists.

These Summer Schools have provided very encouraging environment to the awardees and there were sufficient opportunities for a scholar to obtain maximum benefit by participating actively in the programmes of these schools.

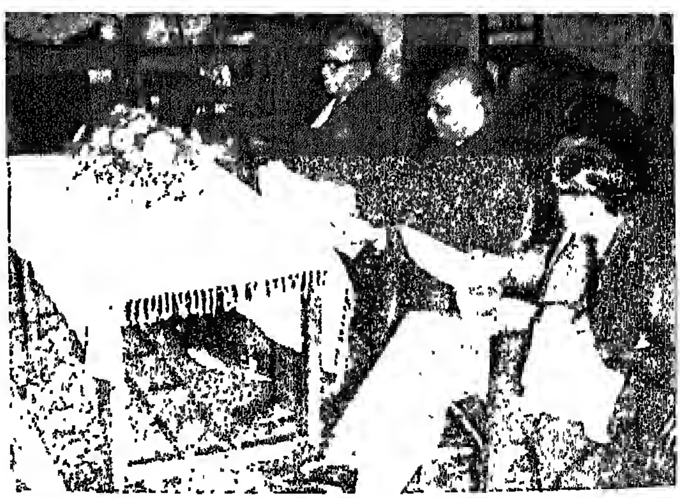
Science Talent Awardees at work in the Summer Schools

REFRESHER COURSE IN BIOLOGY

A 10-week refresher course was organized by the State Institute of Science Education, Bangalore to give a short-term training to the biology teachers of the Mysore State. It was conducted at the Regional College of Education, Mysore and the Teachers' College, Mysore. The purpose of the course was to acquaint the biology teachers with modern concepts and trends in biological science so that they may improve their methods of teaching biology in their schools. Eleven teachers of biology from all over the State participated from May 10 to July 18, 1965. The syllabus followed in this course was prepared by the Department of Science Education of the National Council of Educational Research and Training, who also deputed for a week one of their officers to help in organizing and giving a start to the workshop. The biology science staff of the Regional College of Education, Mysore, took the help of resource persons from the post-graduate departments of botany and zoology, University of Mysore. Apart from the lectures in the forenoon the accent was on the practicals in the afternoon. The participants have drawn up a draft syllabus of their own

in biology for standard XI which includes some of the latest developments in biology. They have also worked on eight assignments after detailed discussions. Short excursions were arranged to the Mysore Chemical and Fertilizer Factory and the National Paper Mills, Belagola.

The Awardees of 1964 being introduced Dr. S. Radhakrishnan, President



Inauguration of the Science Talent Awardees' 7-day Workshop at New Delhi in December 1964 by Shri L. S. Chandrakant, Joint Director, N C E R T

Books
For your science library

Biology: A Textbook for Higher Secondary Schools. Section 3. 'The Diversity of Animal Life.' P. MAHESHWARI and MANOHAR LAL (Ed) National Council of Educational Research and Training, New Delhi. 1965. pp. 200, Rs. 4 00.

THE first two sections of this book, already published were reviewed in these columns in the earlier issues. Section 3 of the book just released deals with 'The Diversity of Animal Life'. In its 14 chapters the book gives the student a glimpse of the variety of animal life The more familiar vertebrates are dealt with first While dealing with each group in separate chapters, the frog and the human body are taken up in detail in their respective chapters This is as it should be, because the study of frog will lead the student to have a better insight into the working of the animal body. Many of the books on biology published in this country do not deal with the study of human biology. This book deals with it in detail because it is necessary that the student should know more about his own body. The other groups dealt with are the fishes, amphibians, reptiles, birds and mammals Then follows the part on invertebrates or the animals without backbones like Protozoa, Porifera, Coelenterata, Platyhelminthes, Nemathelminthes, Mollusca, Annelida, Arthropoda and the Echinodermata.

Each chapter describes the general character of one group with a number of examples and the highlights of the structure, behaviour, reproduction and other features of the members.

In the first or the introductory chapter attention is drawn to the evolutionary story of animals. The chapter on Mammals includes the human organism. Latest knowledge about blood types, the effect of endocrine organs, etc. are dealt with here. Life span of plants, animals and man and an account of human diseases will be given in the last section of the book.

The present publication maintains the excellent get up and is well illustrated including four colour plates.

S. DORAISWAMI

Biology for Philippine High Schools: Relationships of Living Things. University of Philippines. National Science Development Board, Manila. 1965. Text pp. 662; Teacher's Guide pp. 197.

THE Biological Sciences Curriculum Study (BSCS) of the United States has prepared three sets of teaching materials for a course in biology in the American Schools. Each set includes texts, laboratory manuals and teacher's guides besides several supporting materials. A school is free to choose anyone of these sets. The three versions are called the Blue, the Yellow and the Green versions, each with a different approach. The Blue version has molecular biology as an approach, the Yellow, a cellular approach and the Green, an ecological approach The Yellow version materials were selected by the National Council of Educational Research and

Training for reprinting in India. These materials were used for the Summer Institutes in biology for the past three years.

In keeping abreast of world developments in science education, a number of Philippine educators and scientists investigated the BSCS approach to the teaching of biology. The Committee decided to adapt the Green version because of the availability of flora and fauna all round the year in the Philippines. The Adaptation Committee has published *Biology for Philippine High Schools: The Relationships of living Things*, which is the first biology book for secondary schools in the Philippines. It is claimed by the Committee that the vocabulary has been altered, subjects of special interest to Philippines added, and Philippine and Asian examples used whenever possible

While the chapter headings are the same both in the BSCS Green version and the Philippine book, the matter is suitably and admirably adapted according to the conditions in Philippines. Thus in the first chapter 'The Web of Life', the topic 'Rabbits and Rasperries' is replaced by 'Rice-birds and Rice-plants'. The latter topic is very appropriate for the Far East where rice is the main crop, and the rice-bird is also common in the rice-fields of the Philippines. The figures have also been suitably modified. Wherever sufficient local material was not available the text and examples in the original are retained. This is the case where an original indigenous example could not be cited for the study on the effects of isolation upon speciation (Chapter 17).

From this distance one cannot say how far this adaptation has satisfied the needs of the biology teachers and students in Philippines. The BSCS is actively encouraging other countries to adapt the materials prepared by them. While adaptations can be useful, they cannot exclude or be superior to any original material prepared by competent persons in the country where this is to be used.

While adaptation seems to be good the half-tone reproductions are poor. The print impression of text matter is not uniform on all pages and even on the same page.

Part I of the Teacher's Guide states the general philosophy of the BSCS and the point of view that is developed in the book under review. Part II discusses the Laboratory Section of the course with specific suggestions for its use. Part III includes appendices which contain some general procedures of value to biology teachers and lists of reference materials, equipment and supplies. Thus the Teacher's Guide contains lot of useful material like instructions, recipes for solutions and stains and other matters like the specimens to be studied in the laboratory.

On the whole this is a good attempt at adaptation of a material carefully prepared in another country at great expense. This may be taken as an example for others who intend to adapt one of the versions.

S. DORAISWAMI

Biochemistry—An Introduction. By P. H. JELLINAK. Holt, Rinehart and Winston Inc. New York. 1963. pp. 308.

THIS is an excellent introductory book on the subject of biochemistry for those who are out specializing in this field. The importance of this subject as a border line

science requires no emphasis and to the ordinary science graduate it is vitally important to know this rapidly advancing branch of science.

The book explains in a comparatively simple language the main biochemical concepts and the modern analytical methods. After introducing the reader to the living cell and metabolism of the body, the methodology of biochemical studies is given, familiarising the reader with the modern techniques. The physico-chemical principles are made clear. The chemical nature of enzymes, nucleic acids, photosynthesis, and metabolism of proteins, carbohydrates with special stress on glucose have been developed lucidly The role of RNA in protein synthesis and the functions of DNA in the mechanism of heredity have been described. A descriptive account of hormones and vitamins with special reference to their role in human metabolism is given without any emphasis on the chemical structure and synthesis, which are normally dealt adequately in standard chemistry books.

The book will be of interest to science teachers and undergraduate students in science, home science, agricultural bacteriology and pharmacology

There is a useful bibliography at the end.

N. K. SANYAL

The Development of Modern Chemistry. By AARON IHDE. Harper & Row, New York. 1964. pp. 851.

IN this volume Prof. Ihde presents the phenomenal growth of chemistry as a science from the ancient to the modern times.

The flow of historical events has been described by giving accounts of individuals and institutions who have influenced the development of the main ideas. It has been shown that not only alchemy, but medicine and technological arts were the precursors of modern chemistry. The volume abounds in figures and portraits of chemists ancient, mediaeval and modern, mostly repr oductions from original sources.

The book is divided into four major parts Part I deals with the foundations of chemistry, alchemy, medicine and technology of the ancient times with a heritage of speculative concepts which gradually gave way to the empirical concepts based on the experimental work in pneumatic chemistry.

Part II deals with the period of fundamental theories from the middle of the eighteenth to the first quarter of the nineteenth century. This period saw the rise of new chemistry, by the death blow on the phlogiston theory and the rise of analytical chemistry. The study of gases leading to the atomic theory, discovery of chemical electricity, knowledge of organic compounds and discovery of many new elements gave the science of chemistry a set of fundamental concepts and the periodic classification which form the base of modern chemistry. The vast accumulation of knowledge gave rise to many unsolved problems.

Part III of the book describes the period of specialization from whence chemistry started developing in inorganic, organic, physical, biological and analytical branches. This period also saw the rise of chemical industries and their impact on our daily life and economy.

Part IV deals with the century of the electron—the development of chemistry in

the twentieth century. The limitations of the Daltonian concept of the atom, the electric discharge in gases and the phenomenon of radioactivity contributed to the modern structure of the atom leading to artificial radioactivity, nuclear fission and fusion, transmutation of elements and exploitation of nuclear energy There was a great extension of the knowledge of thermodynamics, chemical kinetics and chemical bonding giving new concepts of atom-molecular structure New techniques of instrumental analysis opened new vistas of research in organic, inorganic and biochemistry The phenomenal growth of industrial chemistry in various branches is described to indicate the revolutionary changes it has brought in daily life

The four appendices at the end give a time-chart for the discovery of elements, discovery of radio-active isotopes, radioactive decay series and a list of Nobel Prize winners in chemistry, physics and medicine, respectively.

There is an extensive bibliographical notes, chapterwise, of about 65 pages covering original sources, critical studies, reviews and compilations. This will be helpful to the reader who wishes to pursue the topic further

N K SANYAL

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VOL. IV NO. 3

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INSTRUCTIONS TO AUTHORS

School Science is a quarterly journal intended to serve teachers and students in schools with the most recent developments in science and science methodology. It aims to serve as a forum for exchange of experience in science education and science projects

Articles covering these aims and objectives are invited

Manuscripts including legends for illustrations, charts, graphs, etc., should be neatly typed, double spaced on uniformly sized paper and sent to the Editor, School Science, Department of Science Education, NIE Buildings, Mehrauli Road, Hauz Khas, New Delhi-16. Each article may not normally exceed 10 typed pages.

The article sent for publication should be exclusive for this journal Digests of previously published articles modified to suit the scope and purpose of School Science will be accepted In these cases the name of the journal in which the original article appeared must be stated.

Please do not underline the headings

Selected references to literature arranged alphabetically according to the author's name may be given at the end of the article wherever possible Each reference should contain the name of the author (with initials), the year of publication, the subject title of the publication, the volume and page numbers.

In the text, the reference should be indicated by the author's name followed by the year of publication enclosed in brackets, e g., (Passow, 1962). When the author's name occurs in the text, the year of publication alone need be given in brackets, e g., Passow (1962).

Illustrations may be limited to the minimum considered necessary, and should be made with pen and indelible Indian ink. Photographs should be on glossy paper, at least of post card size, and should be sent properly packed so as to avoid damage in transit

Ten off-prints without cover are supplied free to the authors Extra copies, if required, may be ordered while sending the manuscript, and will have to be paid for by the authors

Improvement of School Mathematics In India

J. R. Kapur

Indian Institute of Technology, Kanpur

A revolution in school mathematics started in the U.S.A. about ten years ago when a number of groups including the School Mathematics Study Group and the University of Illinois Committee on School Mathematics started working supported by large funds from the National Science Foundation and other sources. Very soon quite a number of school mathematics groups were active in writing textbooks, teaching these in schools and in improving the books with the feed-back received from the actual use of these in schools.

The revolution soon reached Europe where the Organization for Economic Cooperation and Development (O.E.C.D.) took the lead. A number of conferences were held and their proceedings (*New Thinking in Mathematics* (1961), *Synopsis of Modern Secondary School Mathematics* (1962) and *Mathematics To-day* (1964), were brought out. Inspired by this effort, many European countries like the U.K., Germany and Belgium began preparing textbooks on new lines. These countries have made notable contributions to school mathematics.

This revolutionary movement reached India about two years ago and the following are the results so far:

(i) In 1963 a Summer Institute in mathematics for school teachers was held at Delhi. This was followed by four summer institutes in 1964 and by sixteen in 1965. In these summer institutes about one thousand school teachers and one hundred college and university teachers participated. S.M.S.G. books were used in these institutes and about forty American consultants who had used these books earlier also attended.

(ii) A Mathematics Textbook Panel for writing books for classes I to XI has been appointed by the National Council of Educational Research & Training. Textbooks prepared by this panel are expected to be ready during the course of this year.

The present article may be regarded as a continuation of 'Revolution in Secondary School Mathematics' published in *School Science* (1964).

A Professional Organization of Mathematics Teachers

Such an organization can accelerate the pace of the revolution by bringing together all the teachers who have come in contact with modern mathematics, by providing a forum for the discussion

of problems of mathematics education, by presenting government, parents and educational administrators with the views of teachers, and by giving teachers a sense of unity in a common endeavour. Such an association was formed at the Simla Summer Institute of 1954, but does not seem to have been active. Some enthusiastic teachers in Madras have been trying to persuade the Indian Mathematical Society to form a School Teachers Wing, but they have not succeeded so far. Another group of enthusiastic teachers at Lucknow formed the Lucknow Mathematical Association and organized a course of lectures on modern school mathematics. This course was attended by a large number of school teachers from the region. Similar seminars for school teachers of Delhi had been organized in 1960 and 1961 by the Mathematics Seminar of Delhi University.

The importance of an All-India organization with branches in all the states cannot be over-emphasized in a democratic country like ours. It is hoped that such an organization will soon be set up and that at least all those school teachers, who have participated in the summer institutes will soon join it The government can encourage the formation of such an organization by giving it liberal grants and by encouraging all past and future participants in summer institutes to join.

The Need for a Mathematics Education Journal

At present there is only one journal, namely *The Mathematics Student* published by the Indian Mathematical Society, which tries to meet this need, but it hardly provides twenty or thirty pages in the year which may be of any interest to school teachers. Another magazine *The Mathematics Teacher* started recently from Madras, is trying to meet the needs of lower secondary school teachers. The need for such a journal dealing with mathematics education cannot be questioned In fact most of the participants at Summer Institutes whom the author has met have asked him to suggest an Indian journal to which they or their school libraries could contribute It is hoped that the Indian Mathematical Society, the National Council of Educational Research and Training, the various education departments and teachers will give the Society sufficient support to enable the journal to make an effective contribution to school mathematics.

The Need for New Indian Textbooks for Schools

The national panel is doing its best, but the progress is slow Its members are busy persons and can give only a fraction of their time to this important project. The work requires the full-time attention of some mathematicians and the government should persuade at least six to undertake the work on a full time basis. Some of the school teachers who have participated in the summer institutes should also be associated with this undertaking.

Study of Foreign Mathematics Projects

At least a dozen different sets of good textbooks have been produced by mathematics teaching projects in the

various countries. It is highly desirable that we benefit from the thinking that has gone into the writing of these textbooks. At present the S.M.S.G. set of books is the only set which has been studied to some extent in our country. These books are excellent, but they cannot be adopted in our country for obvious reasons. Even in the U.S.A. these books have not been universally accepted, there they are trying out different sets of books in different schools. Mathematicians have not yet reached a finality in their mathematics programmes and it will be harmful for us to adopt what they themselves regard as tentative. Some of the British and continental books, however, develop ideas which are more suitable for our country. It is obvious that we should take the best from everywhere and adapt it to our needs. For this, intensive study of all the different textbooks will be necessary, this will have to be undertaken by a number of groups. Such groups should be formed and a great academic debate should be encouraged among these groups.

Clarity about Future Syllabi

A good deal of thinking has to be done before we decide about our future syllabi. We have to decide carefully as to what topics have to be deleted from our existing syllabi and what new topics have to be added and also in which topics the emphasis has to be changed. Simply saying 'we must change,' leads us nowhere. We may remember that Russia is changing very slowly and yet she is doing quite well in mathematics. We must keep the needs of university and research mathematics in view, but we must also keep in view the needs of the consumers of mathematics, viz., physical and social scientists, biologists, engineers and business managers. We must make our presentation abstract, but not too abstract. The subject must be understandable to the child and he must be able to enjoy it; at the same time, contact with applications should not be given up. Most people in our country have very hazy concepts about the changes and it is better to think, discuss, argue and wait rather than introduce ill-conceived and ill-designed syllabi.

Adequate Preparation by Teachers for the New Programmes

Attendance at one summer institute does not necessarily entitle a teacher to teach according to the new programme. Much deeper thinking and involvement are required. Those teachers who may be called upon to undertake this new teaching should be given much more intensive training, and even after that they should be constantly helped by more competent persons during the course of the first or second year of their teaching.

Experiments in Mathematics Education

At present we have huge examination boards in the various states, which examine sometimes lakhs of students at a time. It is impossible to introduce new syllabi in such boards, as satisfactory arrangements for teaching the large number of students involved are impossible. It is suggested that in each state separate examination boards be formed in each university town, e.g., in the

Uttar Pradesh secondary school boards may be formed for Agra, Allahabad, Kanpur, Lucknow, Varanasi, Aligarh and Gorakhpur cities. The present U.P. board can continue for the rest of the state. These new boards may be under the academic control of the corresponding universities. Each university may set up a school mathematics study group to train the teachers of the city for a year and may then introduce new syllabi according to textbooks that may be prepared by a panel common to all the universities. The university teachers can act as consultants for the first two or three years for these courses. Similar study groups in other subjects like physics, chemistry, biology, history etc., can be formed in each centre. These groups should be financed by the centre. Similar boards can be created at all the university centres in all the states.

The Delhi State already has a board of Secondary Education. It has a board of qualified school teachers and in Delhi University there are mathematicians who have taken interest in school mathematics. An integrated programme for improvement of school mathematics can be immediately undertaken in Delhi State.

Publicising the Need for Change

All programmes for improvement of mathematics education will require vast funds and the tax-payer must be convinced that improvements in mathematics are of vital interest to the development of physical and social sciences and of our technology. Parents must be convinced that mathematics has made revolutionary advances and as such their children have to study a type of mathematics different from the one they themselves learnt. Educational administrators like Principals and Directors of Education have to be convinced of the necessity of working for a smooth transition. Among school teachers enthusiasm has to be aroused about the new programmes, for without their whole-hearted co-operation no reforms can succeed. University teachers have to be persuaded to put aside part of their time for research in the interest of schools so that ultimately they themselves may get better students than they do today. Thus large-scale publicity on a number of fronts is an immediate necessity.

Participation of University Teachers in the New Programmes

The need for change in school mathematics has arisen mainly because of the exponential growth of mathematics. Only those who are at the rapidly advancing frontiers of knowledge in pure and applied mathematics can say what topics in school mathematics have become useless and what new topics and concepts are assuming greater importance for the further development of mathematics and science. University teachers are more likely to have such a broad perspective than school teachers, but this is not necessarily true for all college and university teachers. Most of them know only the mathematics which they had learnt in their college days and that mathematics may be eighteenth or early nineteenth century mathematics. Even those who may have done good research work in their

narrow special fields may be hopelessly out of touch with modern developments in pure and applied mathematics. Mere seniority in university service may not qualify a person to contribute to school mathematics. A great deal of reading and thinking has to be done even by university teachers before they can make an effective contribution to school mathematics, but it is obvious that if they give even some part of their time to school mathematics, they can make a very useful contribution.

Specialized Courses in Universities for Future Mathematics Teachers

At present we teach the same mathematics to all students at the undergraduate level, irrespective of whether they want to become researchers in pure and applied mathematics or engineers and scientists or school teachers. For those intending to become teachers in secondary schools, an M.A. course of different content can be designed. Some of the topics in the existing M.A. course, which have no appreciable impact on school mathematics can be dropped and some others like set theory modern algebra, foundations of Geometry, non-Euclidean Geometries, mathematical logic, social and industrial applications of mathematics and probability and statistics can be given much greater importance. At least one or two special papers dealing with such topics can be introduced immediately.

Research in Mathematics Education

Tackling problems of mathematics education may require as much originality and creativity as tackling problems in any branch of the subject itself and as such mathematics education should be recognized as a respectable field for research in mathematics

An Alternative Syllabus in Mathematics

A tentative alternative syllabus in mathematics for secondary schools may be immediately drawn up. The various boards should be persuaded to accept this alternative syllabus. Both the existing syllabus and the new syllabus may exist side by side and those schools which may want to opt for the new syllabus may be encouraged to do so. Only those teachers who have been trained in the summer institutes and who pass a specially designed qualifying examination may be permited to teach this new syllabus. In course of time more and more schools are expected to offer the new syllabus and thus a smooth transition may come about.

Recognition and Reward to Teachers who Teach New Syllabus

Teachers teaching the new course will have to put in much harder work than those teaching routine courses. They must therefore be given some facilities, e.g., one period of the new syllabus may be recognized as equivalent to two periods of the old syllabus. These teachers may also be given facilities to participate in conferences and seminars to discuss the implications of the new syllabus. In addition, monetary rewards in the form of special increments may be given to all those who pass the qualifying examination and who undertake

the teaching of the new syllabus. Professional recognition of the pioneering work done by the teachers must also be encouraged. A suitable system of incentives for spreading the new syllabus should be worked out and implemented

More Rigorous, Axiomatic, Logical and Abstract Representation of the Subject

Mathematics is a dynamic intellectual enterprise in which abstraction, generalization, logic, axiomatic method, consistency, etc, play an important part. The teaching of mathematics should include the teaching of the mathematical habit of thinking. One of the criteria for choosing topics for schools should be to see whether these topics and the methods of presenting them demonstrate the spirit of mathematics. Thus Euclidean geometry as taught today is not strictly logical and its teaching has to be modified. The axiomatic method of presenting algebraic structures is not used, this must be explicitly brought out. Concepts must be given greater importance than mechanical drill. A student must not only know the algorithms for finding H.C.F., L.C.M., square root etc., but he must also know the why and wherefor of these algorithms. A mathematician is not just a technician, he is a scientist as well.

Contact of School Mathematics with Realistic Applications

Mathematics has always derived its greatest strength from applications. Even at the school stage these applications should be taught. Subjects like the mathematics of finance, algebraic economic models, simple inventory models, linear programming, mensuration, probability and statistics, etc., should be taught. Greater use of mathematics in courses of physics should be encouraged and for this, topics like vectors may be included. The student should develop the faith that mathematics can help in solving all types of problems in physical, biological and social sciences and in industry and technology

Creating Enthusiasm Among Students

Some of the teachers trained in the summer institutes have already started teaching S M.S G books to some of their brilliant students, even when these books are not part of the prescribed course and the response of the students has been very encouraging. Such instances of initiative on the part of the teachers are most welcome and should be encouraged. In any new programme, the co-operation of the students is most welcome. The students must feel that they are pioneers, at least they should not feel that they are guinea-pigs.

Mathematics Clubs in Schools

These clubs can organize debates, discussions and exhibitions. They can celebrate the birth anniversaries of great mathematicians. A certain high school in Madras has been organizing an exhibition for a number of years and a great deal of enthusiasm has been generated among the students of that school. Mathematics provides a large number of games and puzzles which stimulate thinking and illustrate mathematical principles.

Impressive Dynamism of Mathematics

There is a widespread feeling even among educated classes that mathematics is static and that no new worthwhile research is going on in the subject. This feeling is strengthened by the fact that our syllabi in schools and degree classes have not changed substantially during the last fifty years. The fact that mathematics is dynamic and doubles itself every eight or ten years is not sufficiently appreciated by the public, by the teachers of mathematics and by the students. This fact of dynamism has to be given abundant publicity so that bright students are attracted to mathematics.

Attracting Bright Students to Mathematics

For first rate science and technology, first rate mathematics is essential and for first rate mathematics, first rate minds are essential. Unfortunately at present the best students are not being attracted to mathematics. Not more than five per cent of the students selected in the Science Talent Search Scheme offer mathematics in their degree classes. This is unlike the situation in the U.S.A. and the U.S.S.R. where the best students are going in for mathematics. Active steps have to be taken for remedying this state of affairs. Employment opportunities for mathematicians are not inadequate even today, but more opportunities are likely to arise as industry develops. Computer development is likely to be another good source. The Council of Scientific and Industrial Research is spending not even one per cent of its budget for research in mathematics. Its expenditure on research in mathematics and mathematical sciences must increase rapidly. The scope for making scientific contributions of the highest order in mathematics should be well publicized. Applications of mathematics in the various fields of science and technology must also be published. The government must provide adequate scholarships in mathematics at the undergraduate and M.Sc. stages.

Organizing Competitions in Mathematics

In the U.S.S.R. and East European countries, mathematical 'Olympics' have played an important part in discovering mathematical talent and encouraging it. In the U.S.A. too, national competitions are serving a useful purpose. Competitions should be arranged at different levels. Starting with competitions at small regional levels, one can go on making successive selections and finally arrange a competition at the national level. These competitions can supplement the existing Science Talent Search Scheme. In any case the latter is not serving as useful a purpose for mathematics as the mathematics olympics would do.

Encouraging Creativity in Mathematics

Mathematics education in our country has come to be identified with a mechanical solution of problems. The aim of education however is not just acquiring knowledge. It is to lead to creativity on the part of the learners. To achieve creativity, problems with varying degrees of difficulty have to be designed by the teachers. Encouragement of self-study by the

students is very important. The student should not only know, but he should be able to apply and to create. Examinations should be intended not only to know what the student knows, but to know what he can create Students have to be inspired to inventive ideas. Writing a good syllabus is not enough. We should have teachers who are themselves interested in creating and in inspiring their students to create.

Sequential Summer Institutes

We should have more summer institutes. Those teachers who do well in summer institutes should be invited to join a sequential summer institute the following year where their training should be further strengthened. Those who can complete three sequential summer institutes should be given a diploma and entitled to teach the new courses. They should also be entitled to promotion. During the next two or three years our effort should be to produce about five thousand teachers who can teach the new ideas to about two lakhs of students.

Correspondence Courses for Teachers

Summer Institutes tend to be expensive and we may not be able to afford to train all our teachers this expensive way. Correspondence courses might provide a cheaper and a mass-scale medium for improving the competence of teachers. To encourage teachers to join correspondence courses, these courses should be free and those who complete these satisfactorily should be entitled to increments which should be financed by the central government Correspondence courses can also serve in the follow-up programmes for the summer institutes. Teachers who have attended summer institutes can continue to receive lessons through correspondence for the rest of the year Alternatively only those who show promise in correspondence courses should be invited to join the summer institutes.

Regional Seminars of Summer Institutes Participants

We may organize in the month of December or during Dussehra holidays, three-day seminars of all those who have participated in the summer institutes. Thus we may organize about twenty such seminars this year with about fifty participants in each. Each participant can join the seminar nearest to his home. In these seminars, teachers should be encouraged to discuss problems of teaching algebra, geometry, trigonometry etc. They may be requested to submit written papers in advance for the seminar.

Revision of Syllabi for Competitive Examinations

Many schools may be inhibited from introducing the new syllabus as they may not like their students to suffer in competitive examinations like the admission test for the National Defence Academy. Normally students are not expected to suffer, as with the new training, they are expected to do better even in the classical type of papers. However, to remove any fears, the U.P S C. may be requested to provide

for some optional questions bearing on the new syllabi.

A Five-Year Plan for School Mathematics

The implementation of the above suggestions should effect substantial improvements in school mathematics, but all these suggestions and others that may be forthcoming should be integrated into a Five Year Plan which should have quantitative targets, which should be realistic, and for which reasonable resources should be made available by central and state governments. There are bound to be administrative bottle-necks, the plan should anticipate these and provide for them. A sufficient number of qualified mathematicians to implement all the schemes may not be available. The plan should take into account this also. The preparation of such an overall scheme is not being attempted here, as it is certainly beyond the resources of an individual.

Ranger VIII's Moon Pictures

R. A. Lyttleton and Peter Stubbs

PRELIMINARY examination of the available small fraction of the 7000-odd excellent television pictures obtained with the cameras on board the Ranger VIII lunar spacecraft shows a number of interesting features not apparent either through a telescope or on the earlier pictures won by Ranger VII. Although the definition appears to be at least as good as that on most of the previous Ranger pictures, the contrast as sharp, and the terrain covered by successive frames more varied, one must nevertheless emphasise at the outset that even when all the data have been analysed in a detailed way, it is unlikely that visual aspects alone can solve the overriding question of the nature of the Moon's surface. Because of widely differing views, it is something about which the scientists must be absolutely certain before they commit humans to manned-landing attempts And it seems probable that this information can only come from soft-landing appropriate instruments on the Moon as is, indeed, being planned by the US National Aeronautics and Space Administration in its Surveyor programme. The first of four Surveyor spacecraft is scheduled for launching either late this year or early next year.

Essentially there are two main hypotheses about what the Moon's surface is made of. One supposes that the Moon has never been molten at all and is compounded of cold dust, probably compacted to some degree over parts of the surface — and certainly compacted by pressure below some indeterminate depth — but conceivably very loose over the Moon's large dark areas, the maria. The alternative hypothesis is that volcanic activity on the Moon is as widespread as it is on the Earth. On this theory, the maria may possibly be huge 'seas' of solidified dark lava.

Before discussing the latest batch of Ranger pictures let us pause and consider the features that are apparent from telescopic observations of the Moon. The most obvious characteristic is the multitude of craters of all sizes, all remarkably circular in outline. They spatter the more rugged 'highlands' of the Moon, but over the dark, flat maria they seem to be much more sparsely distributed, a fact that can be interpreted in a reasonable fashion only by assuming that they must have been filled in or covered over subsequent to their formation. One view, again, claims that the seas and craters in them have been inundated with lava; the other, that they have been effaced by layers of dust. We must remember that it is these

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areas that have been advocated as probably the most suitable on which to land a manned craft.

But what of the craters themselves? Extreme exponents of the vulcanological viewpoint would like them to be the craters of volcanoes. They certainly contain small central peaks in many cases, though many of the structures typically associated with terrestrial volcanoes are absent. But the most reasonable theory is that they are produced by the impact of meteorites. There is no doubt that one would expect such features to persist on the Moon from distant geological times because of the clearcut absence of the strong tectonic and erosional processes that characterise the Earth's surface. The craters, however, have one very marked general feature—they are wide and shallow. The larger ones are proportionately shallower than the small ones in which the depth may be about as great as the diameter. From the sizes of many of them it is certain that the impacting objects that caused them were at least of an order of magnitude smaller in diameter than the resulting craters.

Ten years ago a closely reasoned argument was put forward by Thomas Gold, now professor at Cornell University, New York (*Monthly Notices of the Royal Astronomical Society* 1955, Vol. 115, p. 585) for believing that the craters are the result of explosions. The Earth, and the Moon with it, is travelling through space at a velocity of around 70,000 miles per hour. Meteorites striking the Moon will come in at similar speeds and, it can be argued that they must produce local temperatures of several million degrees. Before the missile gets too deep down in the Moon's surface layers it will have vaporised the colliding lunar material and itself so rapidly that a violent explosion will occur. Because this effect happens comparatively near to the surface the explosion excavates a typically shallow crater. For the larger impacts some of the energy is even directed downwards to begin with at fairly flat angles from the point of the explosion, resulting in a residual central peak.

Such features are not always observed with man-made explosions because these are not usually big enough, but some of the nuclear-test-craters produced in the Nevada desert do show closely similar characteristics. If the lunar craters are produced in this fashion—and the explanation also accounts for the other salient features which they display — the material blasted out of them must have gone somewhere. Most of it will probably have a high enough velocity to escape from the Moon. But the remainder may form secondary craters at large distances from the original point of impact.

On large-scale lunar photographs older craters show signs of erosion—their rims are broken and blunted, and lower than those of newer craters. Infilling occurs in all degrees. Some craters have simply become flat-bottomed with their central peaks invisible; other have only a low projecting rimlet; while in extreme cases in the maria one can only see a faint white line or the partial circular outline of a former crater. According to Gold they have

simply been buried in dust resulting from erosion. If so, then the burial in the maria is probably much greater than on the high ground of the Moon for it is in the maria that mere vestiges of former craters are most commonly found. The highlands, conversely, may well have been stripped of most of the uncompacted dust, remembering of course that there is no atmosphere and there can be no wind on the Moon, and that some other process has to be evoked to explain the movement of dust.

Measurements of photographs show conclusively that the rims of the larger craters are frequently thousands of feet above the surrounding plain and their floors extend to even greater depths below it. It follows that in the maria there is a very real possibility that the dust may be several thousand feet deep. The point really in question is to decide at what depth this dust becomes sufficiently compacted to bear the weight of instruments and men. Is it five inches, five feet, fifty feet, 500 feet or what? The answer is very difficult, if not impossible to infer with certainty from surface photographs even using the sophisticated techniques embodied in Ranger. Theoretical arguments cannot give estimates of lunar surface conditions sufficiently reliable for manned

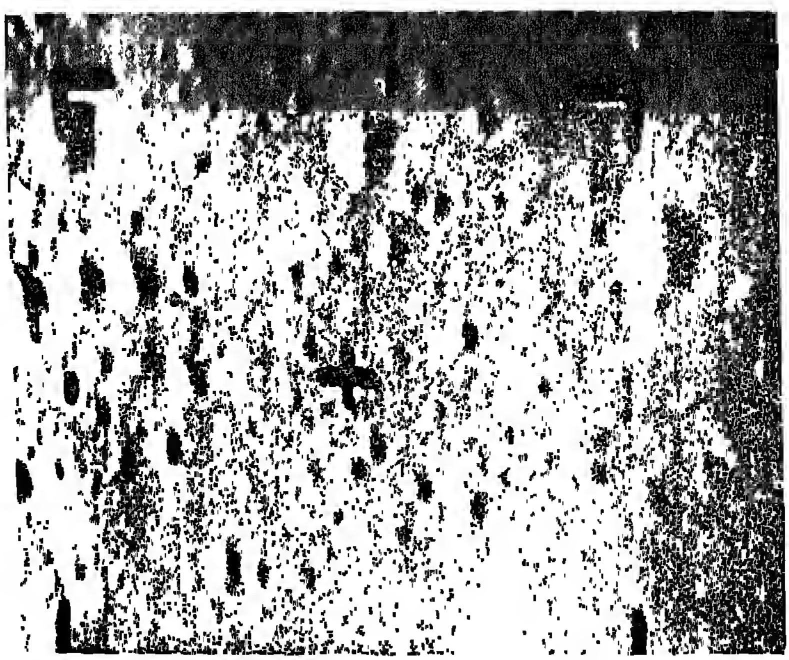

FIGURE 1. *The second to last picture obtained by* Ranger VIII *from a height of 2400 feet, 0.4 seconds before impact. It represents an area 400 feet by 300 feet and the smallest craters visible are about five feet in diameter*

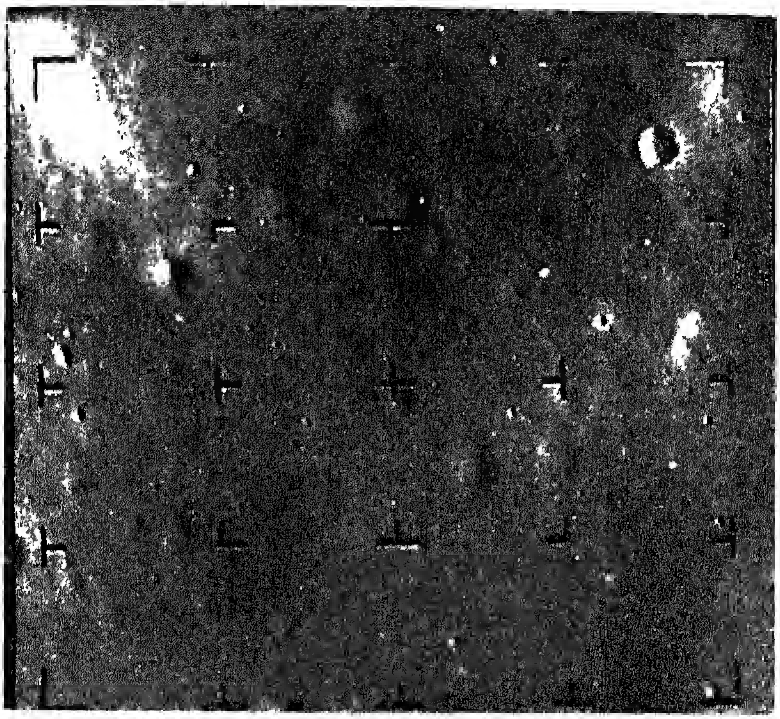

FIGURE 2. *The Mare Tranquillitatis from 5.1 miles up. Most craters have soft outlines indicating erosion and infilling. One, 200-300 feet across, is evidently younger with a sharp rim and small central peak*

landings as there are too many unknown factors The combination of a vacuum with the high temperature variation (about 300°C) and the undiluted ultraviolet light from the Sun, may result in unusual processes, but they are very hard to test in a laboratory. Factors like these may also play a part in the erosional mechanisms.

Gold's arguments have considerable weight. Craters due to volcanic processes would be expected to have steep sides ascending to an elevated peak, itself showing the characteristic vent of a pressure-burst, as opposed to an explosion. Moreover, if the infillings are of a lava or perhaps, as Dr. Gerard Kuiper suggests, a frothy kind of pumice, there is no reason why older craters should be the most extensively inundated. The creative ages of craters can be independently fixed by observing that younger ones intersect older ones. Gold's study shows that there is never a disparity between the relative ages determined in this way and those determined by the degree of infilling.

A preliminary glance at Ranger

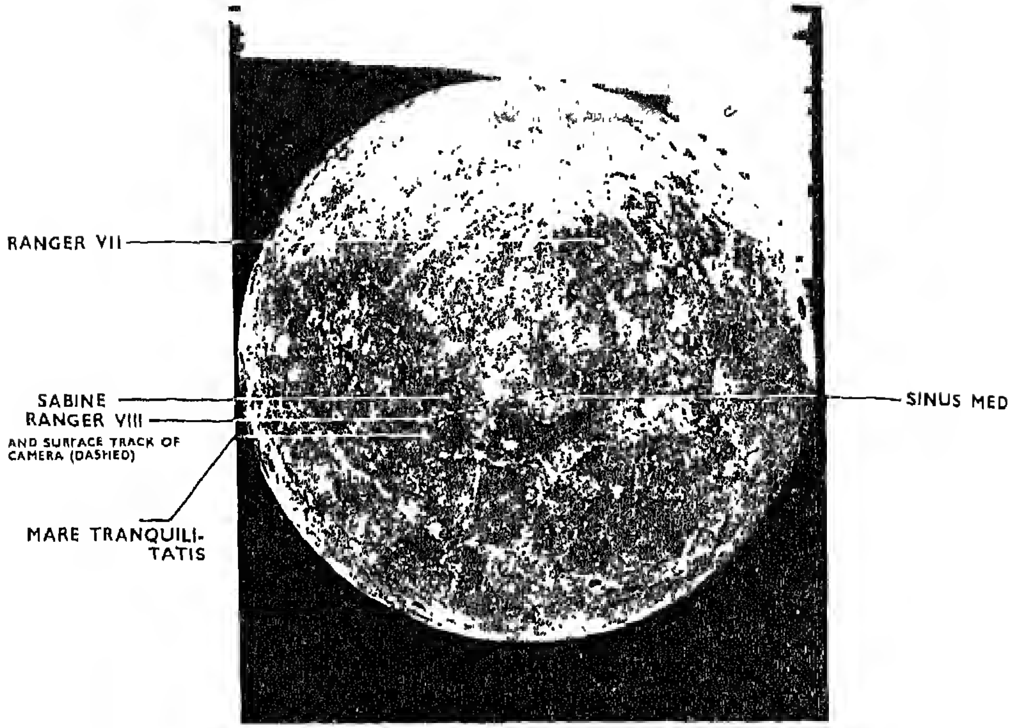

FIGURE 3. *Photograph of the Moon showing the impact points Ranger VII and VIII and (dashed) the track of Ranger VII. (Ranger IX is to be aimed at the Sinus Medii.)*

VIII's pictures reveals nothing at variance with Gold's ideas. The second to last picture taken at 2400 feet (Figure 1) is a little blurred but it, and one taken rather farther out at 5.1 miles (Figure 2) of areas in the so-called Mare Tranquillitatis, have a general texture very similar to that of the area (the Mare Cognitum) into which Ranger VII plunged on July 31 last year. The Ranger VIII photographs so far to hand, unlike one of the most interesting from the previous set, show no obvious signs of boulders reposing in the crater bottoms or elsewhere. The dust is thus probably deeper than the largest frag ments that may occur as a result of meteorite explosions. This fact might also indicate that the dust has little strength on the surface – after all, sand will support very large boulders.

An interesting aspect of Figure 2 i that it shows craters with rounded edges (much like the pictures obtained by Ranger VII) in company with a much younger one with a sharp rim Here, surely, is evidence of erosion and infilling at work. The newe

crater, about 150 to 200 feet across, also has a central peak.

Unlike its predecessor which approached the Moon more nearly head on, Ranger VIII travelled across the surface as shown in Figure 4, which includes the well-known crater Delambre, 32 miles across. An interesting feature of this crater is the suggestion, that its inner walls show of a layered structure. It is probable that heavily compacted dust may have some kind of sedimentary structure. Similar layers appear in some of the larger craters seen with a telescope and it is possible that the explosion has folded back the layers to some extent

Figure 5, taken 50 miles above the Mare Tranquillitatis, reveals two lines of overlapping craters Their linearity suggests a relationship between the objects responsible. In this case they may not be primary explosion craters but secondary ones due to strings of related fragments from some much larger meteoritic impact elsewhere on the Moon.

The two photographs in Figures 6 and 7, covering much the same area, are the most interesting of this preliminary batch. Figure 6 taken from 270 miles up shows the crater Sabine, on the south-western edge of the Mare Tranquillitatis. This crater, and its twin (Figure 7) are each some 16-17 miles in diameter. Running along the 'shoreline' are two parallel linear features which appear to show transverse *en echelon* dislocations at two or three points. In fact, they are visible on the best of the Mt Palomar telescope photographs but in nothing like such fine detail. These grooves

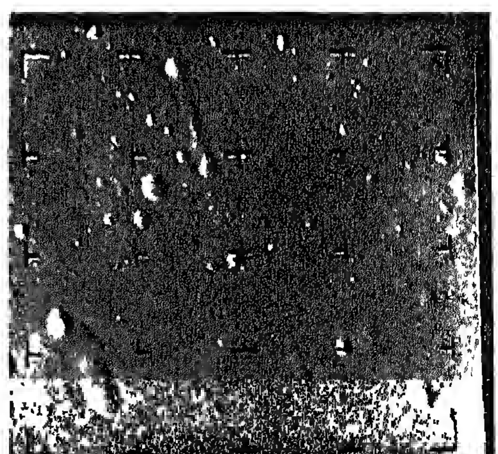

FIGURE 4. *(Left) The crater Delambre near the edge of the Mare Tranquillitatis situated on the Moon's rugged highlands. The crater shows some indication of a layered structure. Picture from 470 miles. Delambre is 32 miles in diameter*

FIGURE 5. *(Right) Overlapping strings of craters in the Mare Tranquillitatis seen from a height of some 50 miles, 45.6 seconds before impact.*

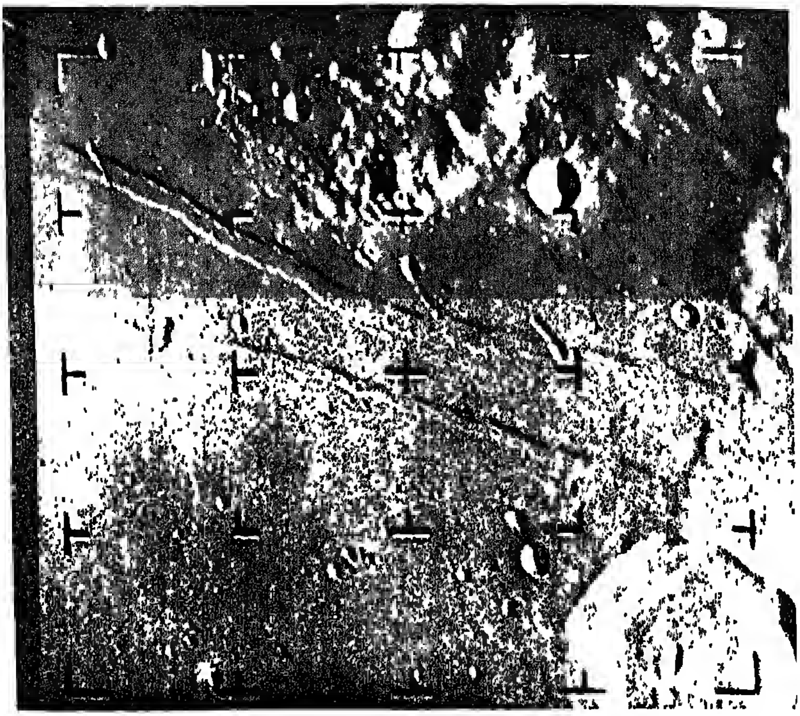

FIGURE 6. *Part of the 16-mile wide crater Sabine on the edge of the Mare Tranquillitatis and two parallel depressions each a mile or two wide which may be expansion rifts. Height 270 miles Four minutes before impact*

are remarkable for their parallelism. They are of the order of a mile or two wide and suggest rifts of some kind, possibly caused by thermal expansion of the Moon. Their seat of origin could lie at a considerable depth below the dust. Alternatively they might be channels gouged out by debris from an explosion, but their shearing and close parallelism makes the former idea more likely.

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In the south-western corner of Fig. 7 there are what appear to be two almost completely effaced craters south of Sabine and its neighbour Ritter. Another curious feature of Figures 6 and 7 is the presence of at least four 'streaked-out' craters. The remarkable thing about them is that, despite their remoteness from each other, the streaking shows an obvious degree of parallelism They do not look like chains of overlapping craters. It is possible that they again represent the result of a number of fragments from a common source elsewhere on the Moon. They almost have the appearance of double craters connected by a channel. They may possibly result from a large impact far to the west.

Neither set of Ranger photographs shows signs of the bright 'rays' that

characterise craters like Tycho and Copernicus and extend over large areas of the Moon's surface. This absence of evidence in near pictures is consistent with other findings that the rays are only very superficial.

Since the only hard parts of the Moon may turn out to be the walls of the well-cratered uplands it would be interesting to know what they are like really close-to. *Ranger IX*, now expected to be launched in mid-March, is to be aimed at the Sinus Medii a rugged area near the centre of the Moon's disc. It may be that the dust is almost absent here and the landing firm. This possibility by no means yet rules out the flat regions of the maria as potential landing sites. For a more positive answer we must wait for results from Surveyor. Whatever emerges from close-up pictures it seems impossible to ascertain the nature of the Moon's surface until equipment has been actually landed on it. And this information is obviously an essential pre-requisite to a manned lunar landing.

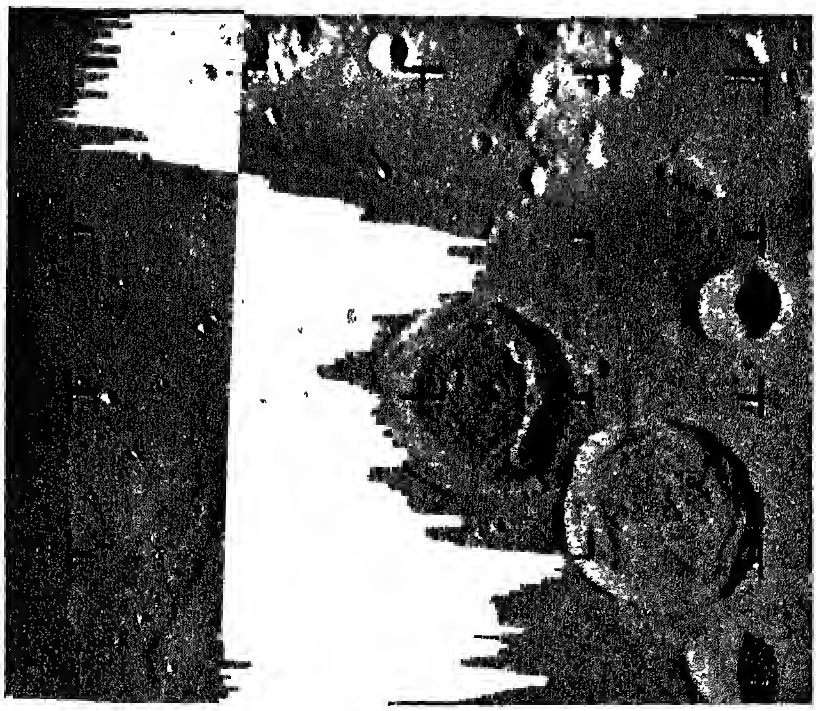

FIGURE 7. *The craters Sabine and Ritter from 151 miles. Two probable effaced craters can be seen in the south-western corner. On this picture and Figure 6 at least four curious "streaked out" craters can be made out all elongated along directions parallel to one another*

Hugo de Vries: Dutch Influence on Modern Genetics

J. Heimans

FOR many centuries both scientists and laymen have based their notions of heredity on the idea of a general type image for every separate animal and plant species as being a theoretical entity of which the living individuals of that species are a realization in time and space — comparable to coins minted from one and the same stamp — and only slightly modified by the direct influence of the parents and of the external conditions of life.

In the 18th and early 19th centuries, vague theories of descent were repeatedly evolved, i.e. conceptions about the origin of new species in nature from older ones by gradual characteristic changes.

The famous British biologist Charles Darwin consolidated these ideas on the evolution of species and pointed out how conditions of environment, diet, predatory foes, etc., might play a part in changing hereditary characteristics.

In this epoch-making book of 1859, Darwin expounded his theory of Natural Selection. With domesticated animals and cultivated plants the breeder succeeds in raising new improved races by selecting from his stock or crop the very best individuals, and by continuing to do so in successive generations.

In the same way — according to Darwin's hypothesis — new species arise in nature, because in the constan struggle for life that goes on amon the numerous and slightly varyin individuals of each generation, onl the strongest and the best adapted t local circumstances may survive an come to propagation.

Darwin's hypothesis of Natural Se lection substantially contributed to th general acceptance of the Theory c Evolution as such. Nevertheless it ult mately does not stand up to scientifi criticism.

One of the most important obje tions is that the very slight improv ment achieved in one generation h to be cumulated through several su cessive generations. But such a cum lation can only occur if the slig modification in the original individua of each generation are inherited l the offspring of the selected fittest.

Darwin and most of his adherer accepted the hereditability of the ever-present individual variations. 1868 Darwin himself, in a not ve convincing chapter ('Provisional Hyp thesis of Pangenesis') of his work *Ai mals and Plants under Domesticatio* tried to show how these individu variations might be transmitted.

It was the Dutch botanist Hugo Vries, who came up with new theor on heredity and evolution, revisi Darwin's views. These theories

By Courtesy Royal Netherlands Embassy, New Delhi

Hugo de Vries provided a sound new basis for contemporary thinking in the whole field of genetics and the origin of species, and gave a most effective impetus to the admirable development of theoretical insight as well as to practical application in these fields of learning.

As early as 1880 he started extensive culture experiments to obtain an insight into the variability of specific characteristic and into the heredity of deviations.

As a result, Hugo de Vries, like his contemporary the German zoologist Weismann, came to refute the hereditability of the so-called fluctuating, ever-present gradual variations upon which Darwin had based his theory of Natural Selection.

De Vries published his theoretical conclusions in 1889 under the title of

Intracellular Pangenesis.

To summarize very concisely and simply, we might say that De Vries's conclusions amounted to the following: Every type of animal or plant is characterized by a great number of specific qualities, which are all inherited unchanged and independently of each other, being as they are bound to separate particles of living matter, called by De Vries 'pangenes'. Each of these pangenes is the carrier of a separate specific characteristic.

All these pangenes are present in the cell nuclei, and — through cell-division—are transmitted to all new cells, including the reproductive cells and, consequently, to all descendants.

As De Vries saw it, the inherited type-image is not one entity, but a mosaic of independent and interchangeable units, though in themselves unalterable.

Hereditary modification can only be caused by the elimination of one of the pangenes, or by the introduction of a new one, or to employ the biological term used by De Vries, by mutation of a pangene.

Selection occasioned by environment can, in contrast to Darwin's views, only be permanently effective if the stock-population already contains some individuals with a fixed hereditary variation, in other words, if one or more *mutations* have previously taken place.

It is only after a number of such mutations have combined to produce a favourable plurality of new characteristics, and the useful combination has been stabilized by the elimination of less favourable competing ones, that a really new species can be said to have evolved.

His paper of 1889 did not at once help De Vries to get these new conceptions generally accepted. The title of his booklet *Intracellular Pangenesis* and the term 'pangenes', deliberately chosen in honour of Darwin, after the latter's *Provisional hypothesis of Pangenesis*, failed to clarify in which fundamental respects the new theses were contradictory to Darwin's. Twelve years later — in 1901 — Hugo de Vries once more published the same ideas on the species as being a mosaic of separate 'unit characters' each transmitted by a pangene; but this time elaborately worked out and sustained by the results of exhaustive pedigree-

cultures and crossing-experiments, in a book under the new title, *Mutation theory*. This work of 1901 (a second part was issued in 1903) made the name of Hugo de Vries famous all over the world, and his once revolutionary ideas have since long become commonplace elements in all theories and methods of research in the fields of genetics and the allied sciences. In his first book on the pangenes, Hugo de Vries had already announced specialized crossing-experiments to confirm his theoretical conclusions. Some of these indeed finally gave the expected simple numerical results, namely, in the second generation after crossing, three quarters of the individuals were like one parent (or rather their one grand parent), and one quarter like the other.

De Vries was startled to learn that these same simple numerical rules of the segregation of hybrids had been found long before by Gregor Mendel as the result of crossing-experiments with peavarieties and had been published in a paper in 1866.

This paper had never been rightly understood and was completely forgotten. For De Vries, of course the significance of Mendel's paper was immediately clear and, by applying his own hypothesis of the pangenes, he was able to extend the conclusions arrived at in Mendel's work much further than its originator had done. Conversely the rediscovery in 1900, of Mendel's laws confirmed De Vries's theory of pangenes as the sound new basis for the doctrine of heredity in general.

Since then experimental research in the field of heredity by means of crossing-experiments with plants and animals has taken enormous strides, and has had extremely important results for practical application in farming and horticulture. In cattle-raising and in poultry-breeding, in foodcrops as well as in flower-culture, superior races of eminent standard value could be bred by crossing and selecting and backcrossing of segregates, using scientific schemes drafted by specialised scientists in experimental stations.

Hugo de Vries in his own further studies turned away from these purely Mendelian lines of research and concentrated on cases in which the Mendel rules did not seem to apply, especially in the plant genus *Oenothera* (Evening Primrose).

It was only after decades of intensely conducted research by De Vries, supplemented by that of Renner, Cleland and others, that ultimately a complete picture could be obtained of the extremely intricate way in which mutation, hybridization and selection, complicated with other, formerly unknown phenomena, fit together in the evolution of new species in this plant genus.

Nowadays we are convinced that the same intensive research will be necessary for the elucidation of this process of species evolution in other groups of plants and animals as well. But in the days of Hugo de Vries's *Oenothera* studies this was not understood. Therefore De Vries, by specializing so exclusively on this labyrinth of *Oenothera* problems, isolated him-

self from all other geneticians who undertook the more conventional kind of heredity research. And this is the main reason why the fame of Hugo de Vries as the originator of the modern views on Heredity and Evolution somewhat declined.

Even in authoritative recent text-books often the most fundamental new conceptions contributed by Hugo de Vries to the doctrines of heredity and evolution, are minimized and treated as having been already implicitly dealt with in the works of Darwin and Mendel. It must be said that De Vries himself, out of profound admiration for Darwin, deliberately omitted to stress the contradiction between his new ideas and Darwin's expressed views.

The Danish author of the first great manual on the doctrine of Heredity, Johannsen, shortened the term 'pangenes' i.e., De Vries's name for the bearers of separate hereditary characteristics to 'genes'. This abbreviated form has since then remained in general use

In recent times the term 'Neo-Darwinism' is often used for the complete system of theories built up by Darwin, as reconstructed with the aid of modern research and the application of present-day conceptions. There is little occasion for objection to the term 'Neo-Darwinism', as long as it is remembered that the major corrections to Darwin's original ideas have been derived from Hugo de Vries's doctrine of the pangenes.

Hugo de Vries was born in 1848 at Haarlem in the Netherlands He studied at University of Leyden and obtained his Ph.D. degree at the age of twenty-two.

His postgraduate studies, pursued in Germany at the Universities of Heidelberg, Wurzburg, Halle and Berlin, already brought him great fame in the field of plant physiology as a result of his experimental analysis of cell pressure and the causes of moisture absorption and growth in plant cells.

After being called to the University of Amsterdam in 1877 as a Professor of Botany he soon started experimental research on the problems of variability, heredity and evolution. Notwithstanding many flattering offers from abroad he remained faithful to the Amsterdam Institute of Botany until he retired in 1918. Then, until his death in 1935 at the age of 87, he continued his work in his own experimental garden and private laboratory.

There is no doubt that Hugo de Vries should be reckoned among the greatest scholars in the annals of science. His work which laid the basis for the great development of the biological sciences in our time has certainly been as important as that of his famous contemporaries, the four Dutch Nobel prize winners Van 't Hoff, Van der Waals, Lorentz and Zeeman, in chemistry and physics. Without such men the world of today would have been poorer indeed.

Nobel Prize Winners in Science—1965

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THIS year's Nobel Prize in physics was awarded jointly to two American and one Japanese scientists, Dr. Julian Seymour Schwinger of Harvard University, Dr. Richard Phillips Feyman of California Institute of Technology, and Dr. Shinichero Tomonaga of Tokyo Education University. Their research dealt with quantum electrodynamics and resulted in easy quantitative calculations of interaction between charged particles. The Nobel Prize in Chemistry was awarded to Dr. Robert Burns Woodward of Harvard University for the development of fundamental techniques for synthesis of complex organic compounds such as quinine, cortisone, cholesterol, strychnine, reserpine and chlorophyll This year's Nobel Prize in Medicine went to three French scientists, Dr. Francois Jacob, Dr. Jacques Monod and Dr. Adre Lwoff, for their discoveries concerning the genetic control of enzyme, protein and virus synthesis.

Physics

Dr. Schwinger was born in 1918 and was educated at City College New York and then at Columbia University. Having taken the Bachelor's degree from this University at the age of 17 years he joined the University of Wisconsin for advanced studies in physics. Later on, while he was engaged in research in Purdue University he was awarded the Ph.D. degree by Columbia University. Next he moved to the California Institute of Techonology and worked with Prof. J. Robert Oppenheimer, a famous physicist In 1946, at the age of 28 years, Dr Schwinger was appointed an Associate Professor of Physics in the Harvard University at Cambridge, Massachusetts in the United States. Next year he was promoted to the full professorship. It is worth noting that he is the youngest professor that Harvard University has had in its three hundred years of existence. Dr. Schwinger has also received the Albert Einstein Award in natural science.

Dr. Feyman was educated at the Massachusetts Institute of Technology where he took the Bachelor's degree. Then he joined Princeton University and got his doctorate. In this university he studied the problem of separation of isotopes of uranium which were badly needed in the early stage of the Manhattan District Project during the World War II in connection with the production of atom bombs. Dr. Feyman was the group leader of the theoretical physicists at the Los Alamos Scientific Laboratory, and he inspected the first test explosion of an atom bomb. After teaching at the Cornell University for some years he joined the California Institute of Technology in 1950. Like Dr. Schwinger, he won the Abert Einstein

Award of $15,000 for scientific achievement

Dr. Tomonaga was born in Kyoto on March 31, 1906. He worked on theoretical physics during the years of 1942 to 1945 when the World War II presented many difficult problems in defence physics. After the war he devoted himself to the studies of quantum electrodynamics.

These three scientists have been honoured for research done by them about 29 years ago. Their research was based on the discoveries of the early 1930's and is regarded as the origin of quantum electrodynamics. During that period, the elementary atomic particle known as the positron was discovered. The positron is a positively charged counterpart of the negatively charged electron. It was also known around that time that when the two particles, the positron and the electron meet, they are destroyed and a photon, the basic unit of radiation, is emitted. Later it was also discovered that there is a reverse reaction, in which a photon, in close neighbourhood of an atomic nucleus, is converted into a positron and an electron. There were enormous difficulties in making any mathematical calculations of this interaction. This year's prize winners discovered independently of each other that the interaction produces a small change in charge and mass. Through the method discovered by the three scientists the changes in charge and mass are now measured very accurately.

Chemistry

Dr Robert Burns Woodward, who has received the Nobel Prize in Chemistry, was born in 1917 in North Quincey in Massachusetts. He studied in a local school before he joined the Massachusetts Institute of Technology. He took the degree of Bachelor of Science at the age of 19 years and the Ph.D. degree the following year. Dr. Woodward synthesized quinine, which is a bitter alkaloid drug used in the treatment of malaria and which is obtained in nature from various species of the *Cinchona* bark. Due to a wartime shortage of natural quinine he was asked in 1942 if he could produce synthetic quinine. After 14 months of intensive work he, along with his colleague Dr. W. E. Doering, succeeded in synthesizing from a coal tar derivative known as benzaldehyde, the first wholly synthetic quinine. The product was announced in April, 1944. Subsequently one after the other, Dr. Woodward made synthetic cortisone, cholesterol, other steroids, strychnine, lysergic acid and reserpine—all considered to be the major chemical achievements of the century. All these are composed of large and very complicated molecules with specific biological activities. His next achievement of major importance was the synthesis in 1947 of 'protein analogues'. They are composed of giant molecules that resemble the natural proteins found in animals and plants. Dr. Woodward's latest success, which is probably the most significant chemical synthesis in the 20th century, is the complete synthesis of chlorophyll. This is the large and complex green pigment in living plants, which carries on the key process of photosynthesis — the process by which plants containing chlorophyll convert water and carbon dioxide of the atmos-

phere in the presence of light into carbohydrates, the food material of the plants. By these synthetic techniques Dr. Woodward has come closer than anyone else to duplicating nature's process of growth. The synthetic techniques used by Dr Woodward in synthesizing the giant molecules has since been of great value to the chemical industries.

His interest in chemistry was first aroused by the gift of a child's chemistry set given to him when he was a small boy. Soon afterwards his parents allowed him to set up a chemical laboratory in the basement of the family home in Boston. By the time he passed high school in 1933, he was reported to have had a greater knowledge of chemistry than most college graduates who majored in the subject He was then only 18 years old. After his doctorate degree in chemistry at the age of 20 years he joined the faculty of Harvard University, and has since been teaching and doing research work there.

Medicine

Dr. Jacob was born at Nancy in eastern France in 1920. He left medical studies to serve in the French Force from 1940 to 1945, and resumed them after the end of World War II. He got the degrees of Doctor of Medicine in 1947, Bachelor of Science in 1951 and Doctor of Science in 1954. In 1950 he joined the Pasteur Institute and started work with colleagues who later became his fellow prize winners. In 1964 a chair was specially created for him and he was appointed as Professor of Cellular Genetics at the College de France

Dr. Monod was born in Paris in 1910. Before he went to the United States, he worked from 1932 to 1936 on some aspects of the origin of life. With a scholarship from the Rockefeller Foundation he received an advanced training in the United States and got his Ph. D. degree in 1941. He returned to the Pasteur Institute and served as a laboratory chief from 1945 to 1953. Next, he became the head of the department of Cellular Biochemistry of the Institute and also Professor of the Faculty of Science. Dr. Monod won the American Bronze Star in 1945 and Leopold Meyer Prize of the French Academy in 1962.

Dr. Lwoff was born in 1902 He studied natural science and took his Bachelor's degree in 1921. He got the degrees of Doctor of Medicine and Doctor of Natural Science in 1927. Since then he has been associated with the Pasteur Institute first as a staff member of the Department of Microbial Physiology, and later as head of the Department at the Sorbonne University. He also served in the French Underground Resistance Force during the World War II and won various medals.

Now the contribution made by these three Nobel Prize winners may be briefly explained. The hereditary information needed to produce enzymes—biocatalysts essential for metabolic reactions in the body—and other proteins is coded in deoxyribonucleic acid, which is the stuff of genes The structural genes are believed to be responsible for biosynthesis of enzymes and proteins. The structural genes serve as templates for producing complementary units of

ribonucleic acid, which, in turn, move to the cellular sites at which the protein and enzyme synthesis takes place. This particular ribonucleic acid is called 'messenger RNA', because it transfers the genetic information and thereby determines the specificity of enzymes and proteins. Previously, a view was held that each gene controlled the synthesis of a particular enzyme. As a result of this year's awardees' contributions it is now known that there is a second class of genes whose function is to regulate the activity of other structural genes which, in turn, direct the synthesis of enzymes and other proteins. They do this by sending chemical signals. So long as the signals are sent and are being received the structural genes are suppressed and no enzyme or protein is synthesized. The French scientists discovered that certain chemicals, if introduced from outside or produced in the cell, interfere with the sending or receiving of these signals. When this interference occurs, the structural genes start the process of enzyme and protein synthesis. This mechanism gives the cell the ability to survive in changing conditions. According to one theory, viruses cause cancer. They live inside cells and become integrated with them. Thus they contain both the structural genes and regulatory genes—the built-in control system—which under certain circumstances can stop the viruses from multiplying. Chemical signals, if sent, by regulatory genes, may cause the viruses to remain in an inactive state and the structural genes will not synthesize enzymes or proteins. But if this process is disturbed, the viruses are activated; they destroy the cells and multiply. This is believed by some experts to be the cause of cancer. As the findings of the French scientists have given great impetus to the development of knowledge in the fight against cancer they have opened up new frontiers of medical research may lead to a practical cure for human cancer.

Frits Zernike and The Phase Contrast Microscope

A. Hugenot van der Linden

On December 10, 1953, the 65-year old Dutch scientist Professor Frits Zernike—the man who made living cells visible—received from the hand of His Majesty King Gustav Adolf of Sweden the Nobel Prize for Physics in recognition of his ingenious Phase Contrast Microscope, by means of which it had been possible to study living cells and which has proved to be of inestimable value to medical research all over the world.

Prof. Frits Zernike

AT the beginning of the century, a young student of chemistry, Frits Zernike, attended an auction sale in his home town of Amsterdam. There he purchased a telescope for a small sum. Little did he realize, as he examined the small pieces of glass which were part of his hobby, that they would eventually make him world famous or earn for him the highest scientific distinction accorded to man.

Zernike was known for his perspicacity. The experiments with light and lenses, which were to fill much of his working life, eventually led him to an amazing discovery, the significance of which was not realized immediately but which eventually brought about a true revolution in the optical study of living tissues so minute as to be invisible to the naked eye and in which an ordinary microscope could produce only vague contrasts.

Now, however, thanks to Zernike's phase contrast microscope—which is as simple as it is ingenious — doctors, biologists, bacteriologists, cytologists and histologists all over the world are able to observe living organic tissues and thus as it were, study life itself as it goes on. Cancer research has probably profited more than any other branch of research from Zernike's discovery. The unending battle against this disease would probably not have reached such a favourable stage as it has today, had it not been for such powerful instruments as the phase contrast microscope. Similarly it has enabled clinical research workers to arrive at a correct diagnosis in a far shorter time. Biologists can now follow the mysterious processes of the division of living cells and cell nuclei; they can observe what is known as 'life' in one of its most fascinating

By Courtesy Royal Netherlands Embassy, New Delhi.

aspects. The cell is the smallest of all the component parts of organic life in human beings, animals and vegetable matter. The phase contrast microscope has made it possible to follow the complicated processes which go on inside such a cell, while they are actually going on. An example of these is the activity of the mitochondriae, those minute bodies which form part of the cell protoplasm. All these processes are closely allied to the secret of life and to the difference between sickness and health. It is not surprising that the Amsterdam University decided in January, 1953 to award an Honorary Degree of Doctor of Medicine to the man whose discovery had made possible all these strides forward in medical science.

At the beginning of the 17th century, when the microscope was first invented, no one was aware that disease and illness could be caused by living objects so small that they could not be observed with the naked eye. Once equipped with the then new and wonderful instrument, the scientists of the day rapidly came to the conclusion that the strangely formed organisms which revealed themselves to their amazed eyes — and which for the sake of convenience they termed animalcules—might well be the cause of the various plagues which afflict the human race.

No one can say exactly when and where the first lens microscope was made. The philosopher Seneca knew that printed letters became larger, and thus easier to read, if they were placed under a glass bowl filled with water, but it took sixteen hundred years for more systematic lenses to be used to penetrate into the mysteries of the microcosmos. That immensely versatile inventor Cornelis Drebbel—a Dutchman attached to the Court of James I of England — must have possessed an instrument with two lenses and this is still regarded as the forerunner of all microscopes. And yet it was the year 1800 before the primitive instruments with which a fly appeared to be 'as big as a lamb' were improved to the point at which they could be used to pioneer medical research.

Thanks to the work of such great experts as Huygens, Newton, Snellius, Descartes and Abbe, much more knowledge had been obtained in the meantime about the laws of light and the phenomena of refraction. Abbe, who was one of the founders of the world famous Zeiss concern, made a particular contribution to the further development of the miscroscope into a refined precision instrument without which physics, medicine and technics would never have reached the high level which they have in our day and age. The microscope emerged triumphant in the period between 1878 and 1924. Beginning with Robert Koch, who got on to the track of the cause of infection in wounds, numerous scientists, including Pasteur, uncovered the secrets of leprosy, typhoid, cholera, plague, malaria and many other infectious diseases.

Shortly before the outbreak of the Second World War, the microscope took a fresh, powerful step forward

with the invention of the electron microscope in which the image was formed not by light waves but by much finer beams of electrons. With its magnification factor of anything up to 100,000, the electron microscope is a large and costly instrument. However, it has the disadvantage that living tissues are killed as soon as they are brought into contact with the instrument. Besides, its size and cost place it outside the scope of the individual scientist.

Long ago the practice of colouring specimens intended for microscopic research commenced; in this way their visibility improved and they displayed the desired contrasts. Unfortunately, however, this practice defeated its object because living organisms did not survive the colouring treatment.

It took a man of the calibre and versatility of Zernike to break this vicious circle. In his scientific career at Groningen University in the north of the Netherlands, he revealed himself not only as an astute theorist but also as an extremely capable experimenter who was as able with his hands as with his brain. An example of this is seen in his ingenious revolving-mirror galvanometer with which even the weakest electric currents can be measured. For years this introvert young man, whose interests hardly stretched beyond his scientific activity, worked on an idea aimed at drastically changing the pattern of the light microscope He extended a theory earlier expounded by the great Abbe on the formation of images. In 1932 he travelled to 'the lion's den', the city of Jena in Germany, where the Zeiss factories were located. There his theories were received with interest, but no more, and he was sent on his way with the remark 'if what you have said had been of any significance, we should have discovered it by now.' The Zeiss research teams were indeed working on the same problem as Zernike. But unlike them, he persevered until he succeeded

The result of Zernike's pioneering work was seen in a theoretical analysis which he published between 1937 and 1942 and in which he set out the manner in which the image in a light microscope is formed. The waves sent out by the small light source travel transversely through transparent preparations and form an image which can be studied through the ocular lens. But what would happen if the various components which constitute the parts of the specimen allowed the light to pass in equal quantities? The result would be a vague image lacking in contrast and extremely difficult to analyse. Fortunately, however, light waves possess a further property: they are not refracted equally when passing through various substances. If you plunge a pencil into a glass of water you will see that it appears to assume a bend, the size of which is determined by the refractory index of water. Each element and substance has a different refractory index.

It was this characteristic which Zernike utilized, and as it turned out to be, this was the answer. The greater or smaller 'bending' which the vari-

ous components of a specimen underwent in the microscope caused a phase differential in the light waves, these, however, are not discernible to the naked eye. The following example will serve to illustrate the principle.

A platoon of soldiers marches, in fours, along a road across which a muddy strip runs at a slant. Soldier No. 1 is the first to encounter the mud and although he continues to march in the same direction he moves considerably slower owing to the resistance of the muddy terrain. Soldier No. 4, however, marches a few yards further before he comes to the strip and thus lengthwise (in the direction of marching) he passes No. 1. The marching ranks have 'shifted' in relation to each other, in other words they display a phase differential. Assuming that the road surface and the strip were precisely the same in colour, an aerial observer would still be able to deduce from the shift that the marchers were on 'fast' and 'slow' types of terrain.

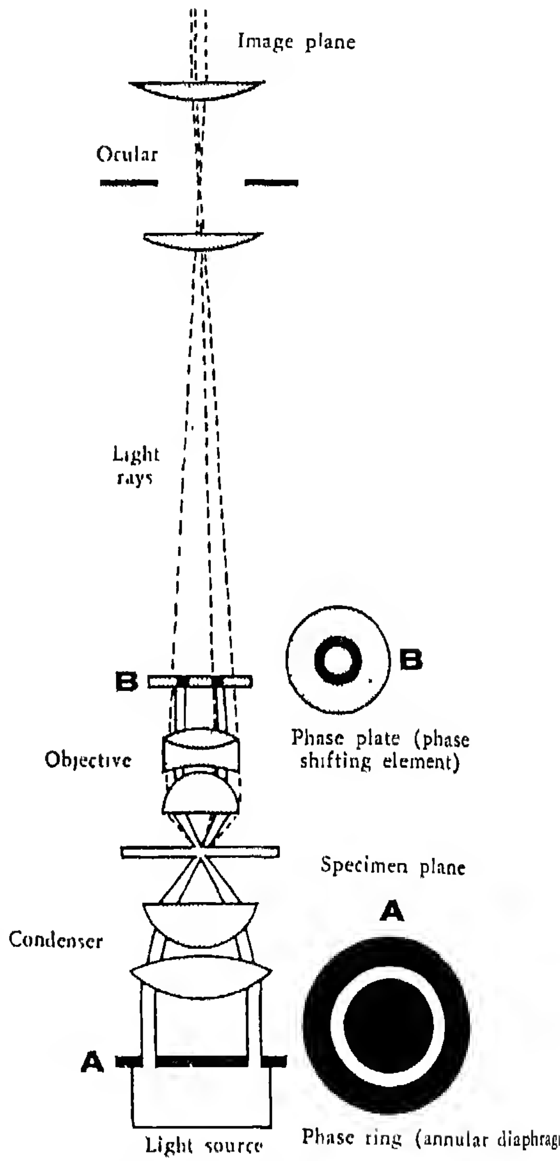
The phenomena of refraction and phase shifting are, in fact, considerably more complicated than in our example. However, the comparison does enable us to obtain an idea of the difficulties which Zernike set out to overcome. He succeeded not only in making the phenomenon of phase differential visible but also considerably strengthened it. Zernike's secret lay in placing two objects in the light rays in his microscope, and together these produced the desired effect. One of the objects was a metal ring and the other a piece of transparent glass ground to a special design; the former he called the phase ring and the latter the phase plate. This plate was anything but easy to manufacture; above all it had to be slightly thicker or thinner in the centre than around the periphery. The difference was only a few thousandths of a millimetre, necessitating an almost impossible grinding operation. But Zernike, born instrument maker as he was, conquered this problem too. His perseverance was more than rewarded because, when his new microscope had passed through the stage of 'growing pains', the improvement in the detail of the living organisms under the lens was so evident that nothing could hinder the success of the instrument. In fact, Zernike had succeeded in turning the invisible difference in the refractory index into visible differences in the intensity of the light passing through his preparations.

The results were more than surprising. A human sweat gland which displayed only vague lines and shapes when examined under a normal microscope, resembled more a hilly terrain with rivers and gullies when examined under the phase contrast instrument, and the contrasts were clear for all to see.

Shortly after the end of the Second World War, a team of American scientists searching amid the wreckage of the former Zeiss factories came across a piece of film showing living, moving tissue. The film had been made with the aid of ideas developed by Professor Zernike. One of the finders, the American bacteriologist John T. Bruce, went to Groningen to

meet Zernike and invited him to visit America. There, in November 1949, Zernike appeared as guest professor and lectured at the Johns Hopkins University in Baltimore to members of the National Academy of Sciences on his revolutionary theories. In November 1951 he was invited to attend the centenary celebrations of the National Bureau of Standards in Washington where he gave a demonstration at which he more than convinced the scientists present of the value of his discovery. Exactly one year later, the famous Royal Society in London awarded him the Rumford Medal for his 'method of achieving an immense improvement in the observation of the fine structures in transparent preparations with the aid of microscopes fitted with so called phase plates'. The Society described Zernike's discovery as the most important one made in the field of light, made during the preceding two years. Other scientific awards followed, culminating in the Dutch professor's presence on the dais of honour in Stockholm on December 10, 1953, to receive from the hand of King Gustav Adolf of Sweden the Nobel Prize for Physics. A member of the Nobel Institute summed up Zernike's life's work in these words: 'the theoretical conclusions which brought Zernike to his ultimate discovery must be called the work of a genius'.

On April 30, 1954, Her Majesty Queen Juliana of the Netherlands appointed one of her greatest but most retiring subjects to be a Commander in the Order of Aranje Nassau. Professor Zernike more than earned the distinction. His phase contrast micros-



Principle of the phase contrast microscope

cope, which is now being manufactured by a number of concerns and is in use all over the world, is a powerful weapon in the hand of the individual scientist in the unabating struggle against the hordes which seek to attack us.

Atom-Molecular Theory And Structure Of Matter At Soviet Schools

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THE atom-molecular theory constitutes the theoretical basis of the course of chemistry at middle schools in classes VII-VIII of the USSR

Since chemists study substances and their conversion, the course of chemistry at school in class VII starts with the introduction of the notion 'substance' based on everyday life and environment. Simultaneously with the introduction of the notion 'substance' pupils are given the notion of the properties of substances. The notion of the molecular structure of substances is also given here. Substances consist of molecules. A molecule is the tiniest particle of a substance. There are interstices between molecules, which can expand or contract. This change in the distance between molecules explains the expansion of bodies on heating and their contraction on cooling. Expansion of a body on heating can be observed with the help of the following simple experiment (Fig. 1).

The flask contains water, is filled up to the cork. A long glass tube is inserted through the cork. Heating of the flask leads to the expansion of the volume of water which begins to rise in the tube. On cooling, the level of water in the flask falls.

After this, the idea is conveyed that forces of attraction and repulsion exist between molecules. Molecules are in constant motion. The speed of molecules of various substances is not identical. This can be observed with the help of the following experiment. Take a pair of small porcelain crucibles and put a few drops of some easily evaporating liquid, for example, bromine in each of them (bromine vapour is reddish-brown in colour and hence can easily be observed). Cover the crucibles with tall glass cylinders. One of them

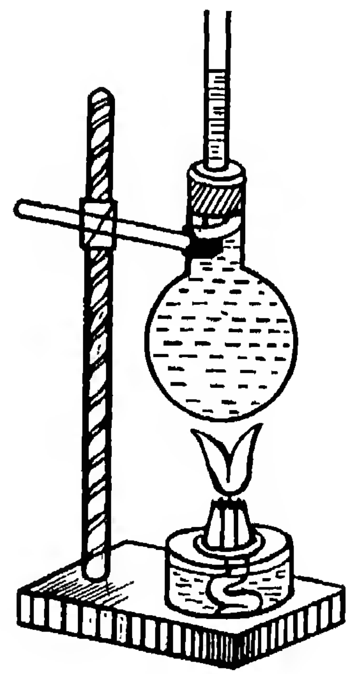


Fig. 1

contains air and the other hydrogen which is the lightest of all gases

Vapours of bromine spread more quickly in the cylinder containing hydrogen (right) than in the cylinder containing air (left). Intermingling of

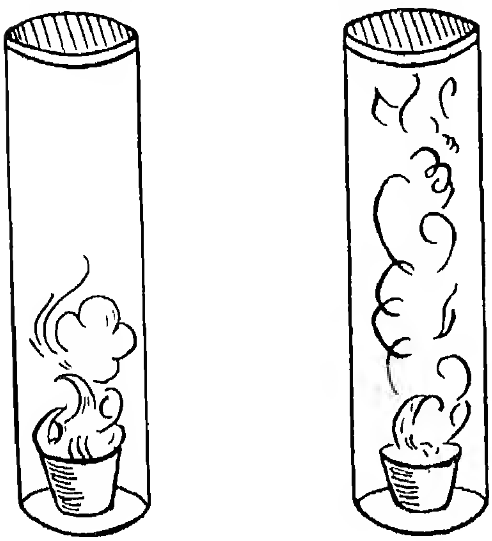
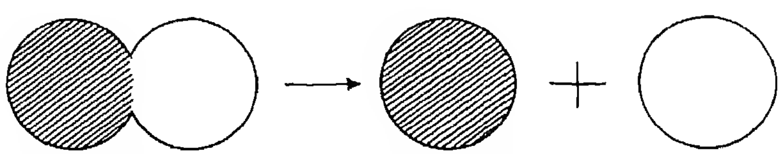


Fig. 2

molecules of one substance with molecules of another substance is called *diffusion*. Besides the laboratory work, some work is also given to be done at home. Put two or three pieces of sugar at the bottom of a glass. Fill the glass carefully with cold water. Taste the water. Has it turned sweet? Cover the mouth of the glass with a lid and allow it to stand quietly Taste the water in the glass again on the next day. Use a teaspoon for ladling out a little of the water from its upper layer Do this carefully without allowing the glass to shake. Does the water taste sweet now? How can you explain the water turning sweet?

The molecular theory provides an explanation for the conversion of substances from one state into another. The notion of chemical conversions (reactions) is given both through comparison and through contrast, that is the notion 'chemical phenomenon' is more comprehensible when opposed to the notion 'physical phenomenon'. To keep the teaching problem simple, chemical phenomenon is sub-divided into reactions of decomposition and reactions of combination. On the basis of examples of 'reactions of decomposition' and 'reactions of combination' the notion of atoms and of atomic weight are given.

The minutest and chemically indivisible particles which form molecules are called atoms.



Molecules of Mercuric Oxide *Atom of Mercury* *Atom of Oxygen*

Weight of atoms expressed in oxygen units is called atomic weight.

The essence of chemical reactions lies in the change of composition of molecules That is why the basic principles of the atom-molecular theory are obli-

gatorily given as follows:

1 Substances are composed of minutest particles, that is, molecules which have interstices between them. Molecules are in constant random motion.

2. All molecules of a given substance are identical. Molecules of different substances differ from one another in weight, dimensions, and chemical properties

3. Molecules are composed of atoms. Molecules of simple substances are composed of identical atoms. Molecules of complex substances are composed of different atoms.

4. Atoms, like molecules, are in constant motion.

5. Atoms of one type differ from those of another in weight, dimensions and chemical properties.

6 Atoms are not destroyed in chemical reactions

Atom-molecular theory has made it possible to explain a variety of chemical transformation of substances.

A molecule is not a simple sum total of atoms. For example, in molecules of iron sulphide you can see neither the properties of free iron nor the properties of free sulphur. As iron sulphide is not a mixture of these simple substances, it is a chemical compound.

On the basis of atom-molecular theory are introduced the notion of element—atoms of one type are called a chemical element—and then symbols of elements and the law of conservation of mass of substance, chemical formula and chemical equation.

For illustration of the law of conservation of mass we may do the following experiments :

1) Burning of phosphorus in a closed vessel, weighing it before the experiment and after it.

2) We undertake another experiment which also corroborates the law of conservation of mass by weighing the substances in the glass trousers before and after the experiment.

After learning the basic chemical notions and getting acquainted vith the atom-molecular study, it becomes possible to examine substances which we study in the remainder of Class VII and Class VIII.

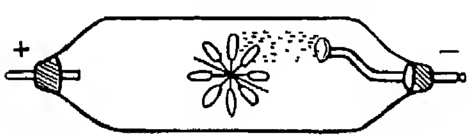
Study of substances starts with oxygen, for the pupils have already some notion of oxygen, air and water from the courses of natural science in Class IV and botany in Classes V-VI. Through examples connected with oxygen, pupils get a more profound knowledge of atom-molecular theory, chemical terminology, oxidation, oxides and valency.

The course of chemistry at secondary school classes IX-XI of the USSR is based on the course of the general chemistry of middle school and consists of two principal parts, inorganic and organic chemistry, which are studied in succession.

At the beginning of the course of inorganic chemistry in Class IX, knowledge received in Classes VII and VIII is repeated and generalized Referring to pupils knowledge of atoms and molecules, information is given of gram-atom, gram-molecule and gram-molecular volume. A quantity of an element whose weight expressed in grams is equal to its atomic weight is known as the gram-atom. (Gram-molecule or mole is the number of grams of a substance numerically equal to its molecular weight).

The periodic law and the periodic system of chemical elements of D. I. Mendelleyev and the theory of the structure of the atom constitute the scientific basis of the course of inorganic chemistry at secondary school and that is why the studying of these problems is placed at the beginning of the course of inorganic chemistry at secondary schools of the USSR in Class IX.

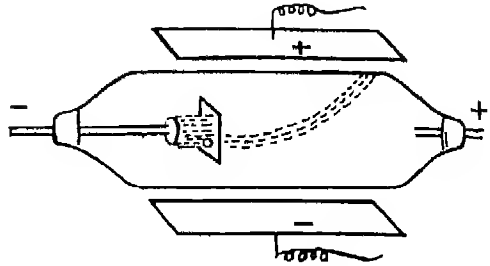
Atom-molecular theory, the periodic law and periodic system pave the way to studying the composition of atom. The first indication that atom



has a complex structure was obtained by studying electric discharge through rarefied gases. If in the path of the cathode rays, a rotator is placed, it starts rotating.

This proves that cathode rays are a current of fast-moving material particles.

If plates charged with electric current are brought near the cathode rays, these rays bend towards the positively charged plate.



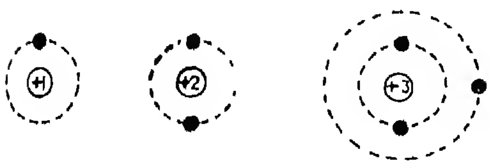
This shows that the particles stripped off from the cathode are negatively charged. The particles which form the cathode rays were named 'electrons'. But atoms cannot be made up of only electrons, since atoms are electrically neutral.

This means that besides electrons, every atom must contain the same number of positive units of charge, as the number of electrons present in them. This conclusion was reached on the basis of the discovery of radio-activity. After studying radio-activity we study structure of the atomic nucleus. This leads to the idea that the atomic nucleus contains protons, and neutrons, and the charge of the atomic nucleus is related to its place in the periodic system of elements. After that, the structure of electronic orbits of the atoms of elements in short periods is studied. This study is made in terms of the Bohr theory. The Danish scientist, Niels Bohr, established that electrons in the atoms are distributed in shells around the nucleus.

Atoms of hydrogen (of ordinal N 1) have a simple structure. One electron moves around the nucleus which has a unit positive charge.

The nucleus of the helium atom (ordinal N 2) has two positive charges and two electrons around it.

Both the electrons of the helium atom move at the same distance from the nucleus and are attracted by it with the same strength.



In lithium (of atomic N 3) we find the same group of two electrons, particularly close to the nucleus as in the atom of helium and above it moves the third electron.

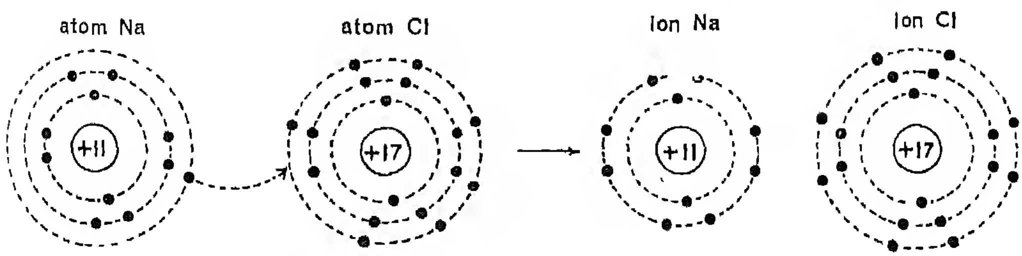
This third electron lies farther from the nucleus and is attracted towards the nucleus with a much weaker force than the first two electrons. Thus, the atom of lithium has two electronic shells: the inner containing two electrons and the other one electron.

On passing on from lithium to beryllium, from beryllium to boron and so on, every time the nuclear charge increases by one unit, the exterior shell acquires one more electron as long as this shell is not occupied by eight electrons. This is attained with neon (No. 10) an inert gas, with which the second period ends.

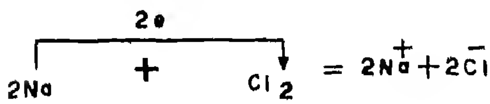
Sodium, the element following neon, has two shells containing 2 and 8 electrons respectively, as in neon, and above it lies the eleventh electron at a much greater distance from the nucleus. Thus, with sodium, the third shell already begins. In this study we found out that the number of electronic shells in an atom is equal to the number of the period in which the element is present. In the outermost shell of the atom of an element, belonging to each main subgroup, the number of electrons present is equal to the number of the group.

The theory of the structure of the atom and the periodic law serves further as a basis for studying the theory of chemical bonds and valency of elements in the light of the electronic structure of atoms. The electronic theory of the structure of atoms explains how atoms combine into molecules. This theory is based on the fact that a completed outer electronic shell, as in the case of inert gas atoms, is found to be a particularly stable grouping of electrons. Hence, inert gases do not take part in chemical reaction.

In the typical metals, the outer electronic shells are least complete: in alkali metals only one electron is present in the outer electronic shell while in metals of the second group, two are present and so on. Thus, a metal can give its outer

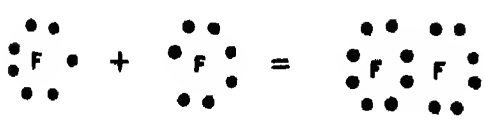


electrons to a non-metal, and a positive charge is produced on the atoms of the metal and at the same time the non-metal atom acquires a negative charge. For example: Charged atoms (or group of atoms) are called ions. If positive charge is depicted by the symbol plus and the negative charge by the symbol minus and the electron by the letter e, then the reaction already considered may be expressed in the form of the following equation:



The chemical bond between ions is called the ionic bond.

Not only atoms of different elements but also of the same element combine with one another forming molecules of simple substances, for example F, Cl etc. And in these cases the union of atoms into molecules provides for the completion of the outer electronic shell of the atoms forming stable shells. But this is realized in a manner different from the manner in which such a stable shell is formed in the case of the formation of ionic compounds. On combining two atoms into a molecule, the two electrons of the two atoms of fluorine, one electron from one atom and another from the other atom of fluorine, become common for both the atoms. Such electron pairs will be represented by two dots placed between the symbols of atoms.



The bond formed between atoms by sharing of electron pairs is called the atomic or covalent bond and the compounds with atomic bonds are called covalent compounds.

The covalent bond exists not only in molecules of simple substances but also in the molecules of compounds between different non-metals

The formation of such molecules are often depicted schematically, in which the common pair of electrons are placed nearer to the symbol of that atom towards which they are displaced.

If the bond is formed by sharing of an electron pair, transferred from one atom to another, then such a type of atomic bond is called a polar bond.

The theory of electronic structure of atoms has helped in understanding the physical meaning of valency. On the basis of structure of atom, it is easy to see that there is a relation between the valency of an element in the main subgroup and the structure of its outer electronic shells. The highest valency, which an element can show in compound formation with oxygen is equal to the number of electrons in the outer electronic shell of the atom. The valence of an element in an ionic compound is equal to the number of units of charge on its ion. For metals the charge is positive while for non-metals it is negative. The valence of an element in a

covalent compound is equal to the number of electron pairs, uniting its atom with the atoms of other elements. After this, it is possible to pass on quite naturally to the study of the general properties of solutions, electrolytic dissociation and modern ideas of oxidation reaction in Class IX.

On such a theoretical basis we study such metals in class X as calcium, aluminium, iron including their metallurgy. After the metals come the non-metals that are representative of the principal sub-groups oxygen and sulphur, nitrogen and phosphorus are studied and finally a study of carbon and silicon facilitates the study of organic chemistry.

The course of organic chemistry has for its foundation the successive application of A. M. Butlyerov's theory of the chemical structure of organic substances. After accumulating certain facts requiring thoretical explanations pupils are given A. M. Butlyerov's theory of chemical structure. The first facts requiring such explanations appear with the study of homologous series of saturated hydrocarbons and their isomerism

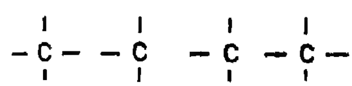
Generalizing several scientific data, A. M. Butlyerov came to the conclusion that to explain them, it is necessary to look into the structure of molecules. Butlyerov proved that molecules of organic substances had fixed structure which can be established experimentally. Consequently each substance can have only one chemical formula The study of building up of molecules from atoms is called the 'Theory of Chemical Structure'.

The fundamental propositions of the theory of chemical structure can be formulated thus:

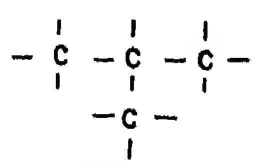
1 Atoms are not crowded in a haphazard manner in molecules. They are joined to one another in a fixed sequence.
2. The combination of atoms into molecules occurs according to their valencies, since no valency unit of the atoms can remain unsatisfied. Carbon is tetravalent in organic compounds.
3. The properties of substances are determined not only by the type of atoms in the molecule and the proportion in which they are present, but also in the order in which these atoms are joined into molecules.

Based on the theory of chemical structure, one comes to the conclusion that in the molecules of saturated hydrocarbons, starting from butane the order in which the atoms are joined can be different.

Thus, in butane $C_4 H_{10}$ the atoms can be arranged in two ways in the form of a straight chain

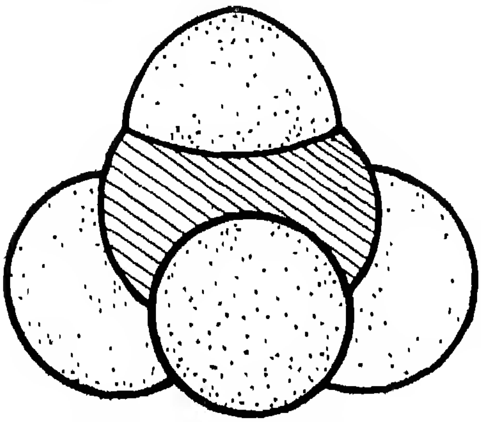


and in the form of a branched chain.



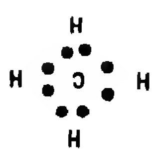
Substances having the same composition and same molecular weight but different molecular structure and hence different properties are called isomers.

Structural formulae of substances reflect only order of atoms' linking to each other. In reality molecules of substances represent stereo figures, e. g., molecules of methane represent a tetrahedron with an atom of carbon in its centre and atoms of hydrogen, in its four apices.



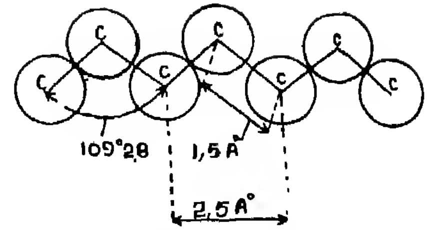
Model of a Methane Molecule

As is seen from the picture of the model of molecule of methane, the atoms of hydrogen are not separated in it from the atom of carbon. Since carbon and hydrogen are not the elements greatly differing in their chemical properties (both of them are non-metals),



electrons when combining do not pass over from one atom to the other but become common constituting electronic pairs.

As a result the atom of carbon gets on outer octoelectronic shell, and the atoms of hydrogen—completed outer organic substances.

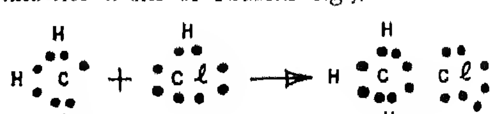


Scheme of Structure of a Carbon Chain

Valent bonds of an atom of carbon are directed to the apices of a tetrahedron; thus they are situated at an angle to each other. These directions are preserved even in case an atom of carbon is combined with other atoms of the same kind.

According to the structural theory hydrocarbons, molecules of which have the composition CH_2, CH_3, C_2H_5 etc., cannot exist in nature. In such grouping of atoms, the carbon valencies are not fully satisfied. Actually scientists could not prepare stable compounds of this composition. However such particles can be formed for a short duration during the course of chemical reactions and then go to compose new molecules. Group of atoms obtained by removing one or more atoms of hydrogen from the molecules of hydrocarbons, are called hydrocarbon radicals

The presence of a free unpaired electron explains instability, high ability of reaction of a radical. With the help of this electron, it quickly establishes a new covalent bond with an electron of another atom or radical e.g.,:



After this the theory of structure is employed as scientific means for comprehending the chemical properties of organic substances.

Central Leather Research Institute

Around the Research Laboratories in India

LEATHER is one of the earliest products that man has used and is using in the modern days. It is associated with the very history and civilization of mankind. We wear leather, walk on it, sit on it but seldom do we talk about it or attempt to know anything about it.

Leather has been serving a multitude of human needs, both in peace and in war, since time immemorial. The caveman used it for covering his body, the forest dweller for his bows and arrows, and the modern man uses it for over 300 different purposes, personal, industrial and defence. Defence requirements have assumed special importance in the present context; leather is particularly needed for boots for our jawans operating under severe wintry conditions at high altitudes.

The superiority of leather over other products lies in the fact that it combines a number of unique properties and can be tailored to suit many specific purposes. For prestige, distinction, individuality and unique quality, for style and comfort, for health and hygiene, there is nothing like leather.

Appreciating the importance of research for the development of the Indian leather industry, the *Central Leather Research Institute* was set up in Madras in the year 1953 by the Council of Scientific and Industrial Research. Madras was selected for the location of the Institute because it is one of the main centres of the Indian leather industry. The Government of Madras gave as a gift a site covering 84 acres in Guindy, Madras. It also spent Rs. 3 07 lakhs in reclaiming the site and diverting the road running through it. The foundation stone of the Institute was laid on April 24, 1948 by the late Dr. Shyama Prasad Mukherjee, the then Minister for Industry & Supply in the Government of India. The Institute was declared open by Shri T. T. Krishnamachari the then Minister for Commerce & Industry on January 5, 1953. Dr. Nayudamma has been the Director of this Institute, since sometime after its inception.

Aims and Objectives

The Institute has been established to conduct research in leather manufacture to ensure that the benefits of new discoveries in that particular science and technology are made available to the Indian leather industry and to promote its development on modern lines. The problems that face the industry are collected from time to time through visits and enquiries and

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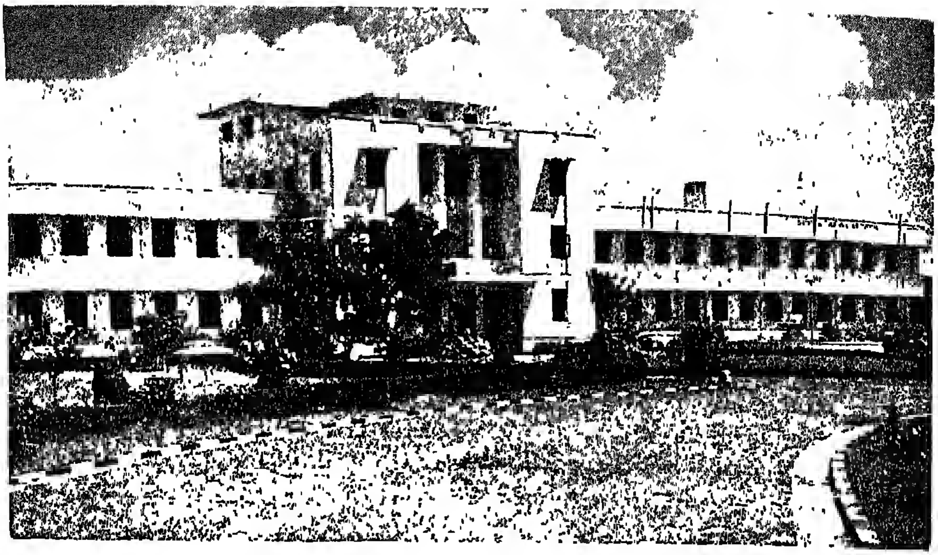
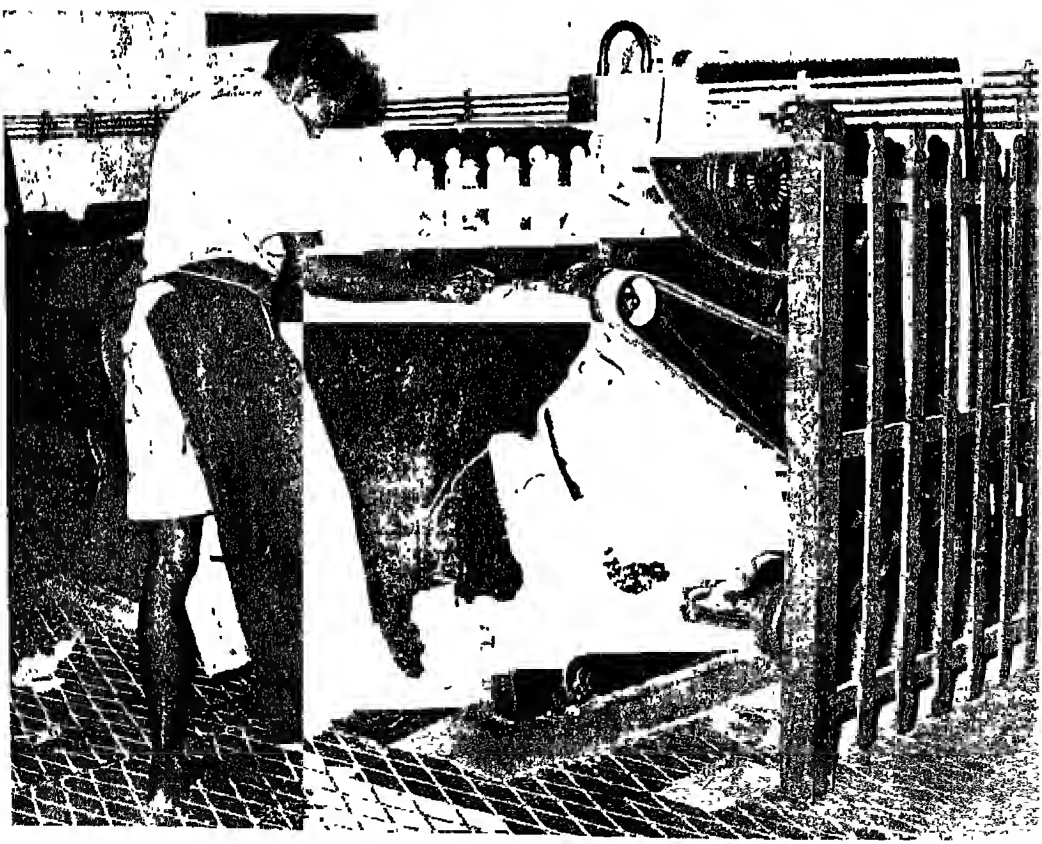


Central Leather Institute Main Building



Buffing Machine

by keeping in close touch with the industry and its activities. The research programme is planned to solve these problems and serve the immediate needs and demands of the industry. Each problem is tackled by a team of research workers and the results are translated and process developed, thus making them ready for immediate commercial exploitation. The knowledge so gained is effectively disseminated in the industry by various means.

The Story of Leather

Not many know how leather is produced. The story of its production begins with the raw material—hides. The raw hide or skin of a dead or slaughtered animal is first cured by removing the water it contains by simple drying, or by the application of salt so that it can be preserved for a period of three weeks to one year, depending upon the method of curing.

When the cured or preserved material reaches the tanner, undesirable constituents like hair soluble proteins and interfibrillary matter are removed by soaking, liming and bating. The hair and the flesh are mechanically removed. The material obtained after unhairing and fleshing is known as *pelt* in the tanner's language. It is a network of interwoven protein fibres. This *pelt* is then tanned with solutions of certain vegetable barks, fruits and pods or synthetic organic chemicals, or mineral tanning agents, such as chrome, aluminium and iron salts.

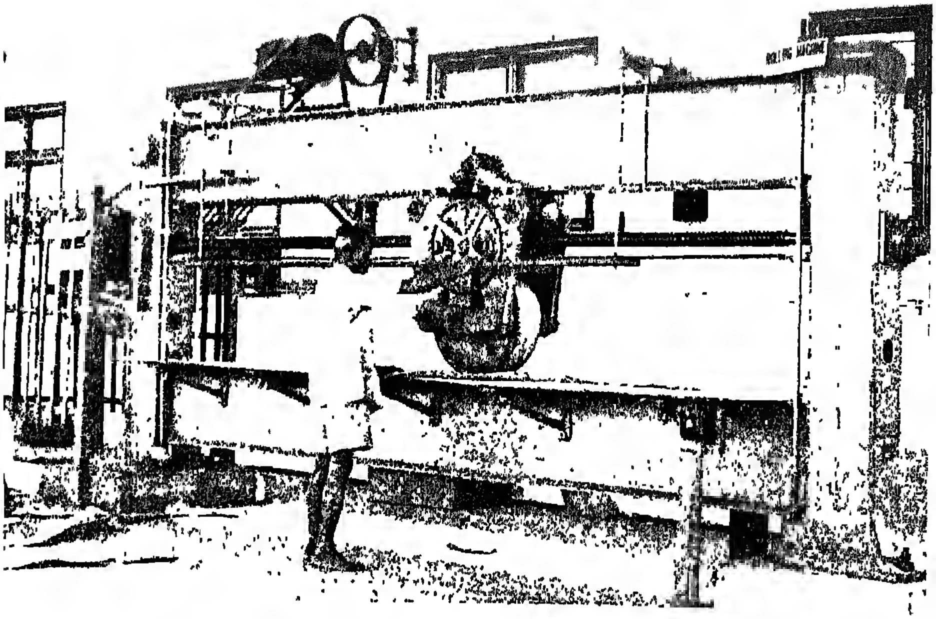
The tanning materials react with the active groups of the protein in the *pelt* and produce leather which is now non-putrefiable and is resistant to heat, hydrolysis and bacteria.

This leather next receives a number of finishing treatments, like shaving, splitting, staking, setting, drying, buffing, etc It is then dyed, curried and glazed to ensure the desired degree of colour, gloss and softness. This treatment is usually given to chrome leather Vegetable-tanned sole leather is oiled, dried, seasoned and rolled to make it resistant to wear and water

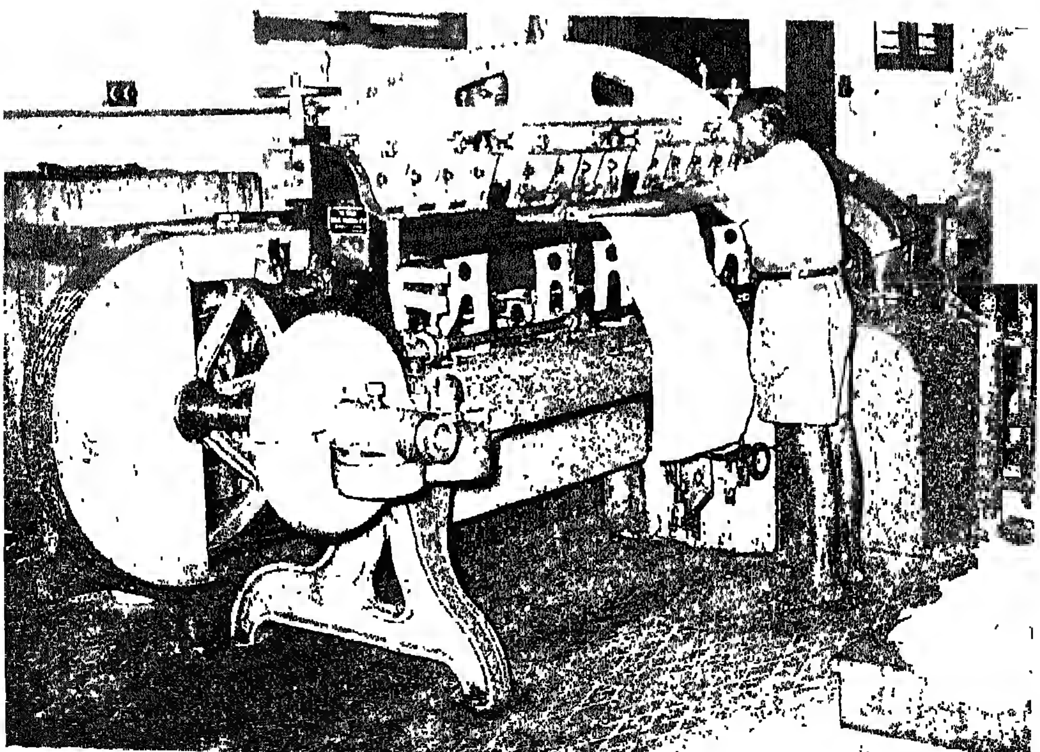
Such is the story of leather—Nature's own miracle fabric—which is processed by the tanner to meet our growing day-to-day demands.

Long Tradition

India is the single largest livestock holder in the world. The leather industry in India is perhaps as old as civilization; it has been, however, essentially a craft practised by the many in far flung villages. It produces every year goods worth Rs. 500 million, and earns about Rs. 350 million in exports alone. The largest single item of use for leather is footwear, which accounts for 75 per cent of the leather consumed in the country. At present 80 per cent of leather is produced in the cottage and small scale industries sector, where the level of technical knowledge is not high and the industry continues to be based more on traditional knowledge than on modern scientific methods.



Rolling Machine



Splitting Machine.

Although the Indian leather industry already plays an important role in the national economy of the country, its contribution could be substantially increased by the adoption of improved manufacturing techniques, and the development of such techniques will be possible only through research.

Face-Lift for Age-old Industry

The type of work being done at CLRI — as this Institute has come to be popularly known — can well be summed up in these words :

(a) conducting research to develop the technical know-how for the better utilization of indigenous materials and production of a wide variety of quality leathers to meet the needs of domestic and foreign markets

(b) Improving of traditional methods of leather production.

(c) Dissemination of know-how developed at the Institute to the industry; and training of technical personnel.

The research programme of the Institute is geared to meet the needs of the leather industry. In formulating its programme, the Institute invites suggestions and holds discussions with manufacturers and consumers, thus gauging their present needs and future requirements.

New Tricks for Old Craftsmen

For curing and preserving hides and skins, *khari* and common salts are generally used in India. Marine salt curing tends to damage raw hides and skins through red heat and salt stains, while *Khari* salt curing loads the material with earthy matter. To eliminate these defects, CLRI has prepared a salt mixture possessing good curing properties; it has been repeatedly tested and found effective both by importers and exporters of dry slated skins. Studies have shown that cured hides and skins can be stored satisfactorily at 60 to 70 per cent relative hummidity and 15–20°C. Work on the control of bacteria and pests that cause damage to raw hides is in progress.

Though the processes employed by the cottage and small-scale tanners serve the purpose, they can be greatly improved by the introduction of fast and economical methods. In the early stages, the Institute gave much attention to the study and understanding of traditional processes, such as E-1 tanning bag tanning, unhairing by akh latex, etc. Developmental work was subsequently taken up to improve the processes. For instance, the duration of the period of tanning sole leather has been cut down from 3 to 6 months to 3 to 4 weeks through improved processes. The indigenous bag tanning process which yielded leather of poor quality in less time and at less cost.

Indigenous tanning materials are not popular with large-scale tanners because of their objectionable colour, slow rates of penetration and fixation, and susceptibility to oxidation. The problem of correcting these defects has been engaging the attention of the Institute for some time. It has now been demonstrated that the tanning characteristics of some of these materials can be improved by chemical

modification or by using them blended with other tanning agents. Over 15 of them, individually or in blends, have been found to be promising substitutes for wattle bark, which is imported from abroad at great cost.

Raw Materials

Eighty per cent of the value of finished leather is accounted for by raw hide. In India the quality of the raw hide is poor and the job of the leather technologist is all the more challenging, since he has to make a good leather out of a bad hide. Stress has therefore been laid on methods of improving upon the quality of the raw hide, on its proper preservation, shortage and transport and also on determining the effect of breed, feed, age, sex, regional conditions, etc., on the quality of the hide and the leather produced therefrom. A monograph based on such a study indicating the biological, histological and bacteriological characteristics of the raw hides and skins of the different regions of this country has been a welcome contribution to the industry. Better methods of preservation by using CLRI curing salt, by the addition of zinc chloride and other preservatives have been proved to be of advantage to the industry.

Another important raw material for the tanner is tanning material. India, to-day imports wattle extract to the tune of about 12 million rupees annually. A number of indigenous tanning materials have been screened and some of them have been proved to be suitable substitutes for imported wattle. But as the various tanning meterials are available only in small quantities, then use in blends is suggested Attempts are being made at present to produce such blended tanning extracts from the indigenous materials for tannery trials in the industry.

The other materials required by the industry are the leather auxiliaries like unhairing agents, synthetic tannins, finishes, oil products and the like. The present day demand is mainly met through import.

The intensive work carried out at this Institute has been the basis for the production industries of a number of leather auxiliaries using indigenous materials. Enzymatic bates, synthetic tannins, fat-liquors, scrylic resin emulsions, neat'sfoot oil, finishes, adhesives, shoe polishes and mineral tanning extracts come under this category. A number of these products produced at CLRI have been repeatedly tested by the industry and reported to be good. It is hoped that the chemical industry will come forward to make full use of the available know-how in this regard. Some of the products like fat-liquors, bates, etc., have already been taken up by the industry.

Know-How and Know-Why

Till recently a wide variety of leathers like belting leather, picking band, etc.. were imported into India. Today India does not import leather or leathers to any extent. On the other hand it imports raw hides for the production of finished leathers. This is because the progress

that has been made by the intelligent Indian tanner by himself and also because of the ready availability of this know-how with the CLRI for manufacture of wide variety of leathers like sole, upper, upholstery, industrial leathers, sports goods leathers, etc. In this respect CLRI has made considerable headway. Process have been worked out for producing a variety of leathers including upper leathers like box and willow sides and glazed kid; industrial leathers like belting leather, roller skins, picking bands, round belts, washers, diaphragm and hydraulic leathers; fancy leathers. The CLRI has not only helped to provide to the Industry with the technical know-how for any type of leather but it has also induced the tanner to take up to this know-how by providing the market for these leathers in some cases. Know-how has also been provided for improving the existing processes, reducing the process time, cutting costs, etc.

What is more important, however, for the progress of any industry is the availability of 'know-why.' The accumulated knowledge, experience and 'know-why' in regard to the manufacture of the wide variety of leathers has made it possible for the CLRI experts to go to the rescue of the tanner whenever and wherever he is in trouble with regard to his production. If only to indicate that research is not done in a monastic environment and that research pays, CLRI has gone out to assist commercial tanneries to run them on profit.

As the know-how is now available, the manufacture of picking bands, belting diaphragm and oil seal leathers has been taken up by the industry and considerable saving in foreign exchange has become possible

Similarly, the Institute is alive to the fostering of export trade and is equipped for providing technical advice on the production of leathers intended for export. For example, the Institute has standardized processes for making sports goods leathers, garment leathers and water-proofing of sole leathers, for softening bristles and for arresting mould growth on leather goods.

CLRI has also forged ahead in solving the problem of utilization of inferior hides for producing leather of good quality. Since there is a ban in our country on cow slaughter, most of the hides available are mostly taken from animals, which meet with natural death, and these are of poor quality. The Institute has developed processes for producing good quality leather from such hides.

Investigations have proved that buffalo hide, which is used at present for making heavy leathers only, can be effectively and fully utilized for the manufacture of other types of leathers also.

Buffalo hide is normally available in three grades: heavy, medium and light. Extra heavy hides can be used for making industrial leathers, like picking band, belting leather and washers. Heavy and medium hides can be split up into three layers. The top layer can be used for making

upper leathers, the second layer for case and baggage leathers and the flesh split for chamois and lining leathers. Light buffalo hides find use in making cheap quality bottom and shoe upper leather like *kattai* and *banwar*. At CLRI pioneering work has been done to produce shrunken grain leathers from buffalo hides.

The formulation of standards for different types of leathers is of considerable importance for domestic and foreign markets and the Institute has been actively assisting the Indian Standards Institution in framing standards and specifications for leathers.

Tanning Auxiliaries

In the process of leather manufacture, several types of auxiliaries, such as oils, pigment finishers, fat-liquors and adhesives, are used. At present, many of them are imported. Work done at CLRI has shown that many tanning auxiliaries can be produced in India from indigenous materials. Enzymatic unhairing agents and bates, fat liquors, emulsifiers, water-proofing compounds, leather finishes, synthetic, mineral, vegetable and oil-tanning agents, adhesives and shoe polishes have been prepared at the Institute. All these compare favourably with imported products in quality and price.

Show-How

The Institute firmly believes that it is not enough to conduct research and develop the 'know-how.' This 'know-how' should be immediately transmitted to the industry As the level of education and the economy of the tanning industry in the country are rather low, a simple and direct policy has to be adopted to disseminate the scientific knowledge. This dissemination, therefore, is done by simple 'show-how,' i.e., by practically demonstrating the process from 'raw to finish' to the tanners either at the Institute or in their tanneries in the different parts of the country. If the product is good and the process economical, the tanner is not so unwise as not to accept it. If it is not profitable the researcher has no business to disturb the tanner who is already making money. This straight, and simple policy of 'show-how' of profits you take, losses we take, has paid rich dividends and has, gained for the Institute a good deal of confidence from the industry at various levels. The Regional Extension Centres at Calcutta, Kanpur, Rajkot, Jullundur and Bombay and the various extension teams of the Institute offer such direct services to the tanner at his own door, speaking his own language

Wealth from Waste

It is reported that the tanneries in India discard about 3,000 tons of scraps and trimmings every year. These waste materials have been utilized for making leather boards of desirable strength, thickness and softness. The boards are suitable for the production of insoles, stiffeners, leather goods, wallets and cases. Methods for converting split pieces into finished fancy leathers have also been worked out. A poultry feed which can be used as

a partial supplement to the normal feed has also been produced from waste fleshings.

Fundamental Studies

The fundamental aspects of leather research are also receiving due emphasis at CLRI. Valuable contributions on the physical and chemical properties of collagen, such as birefringence, hydrothermal shrinkage, optical properties and amino acid composition have been made. Based on a systematic study of the nature of hides from different regions, a histological album is being prepared. Similarly, some significant contributions have been made on the composition and constitution of tanning components and on the biogenesis and biosynthesis of tannins in plants.

Newer Uses for Leather

Work at this Institute has also been directed to develop newer uses for the same leather. Making leathers that are functionally Western, but artistically Eastern by utilising the indigenous skill and artistic talent has brought out a great export potential for leather jackets (embroidered), laminated leathers, Primula leathers, woven leathers for screens, mats, leather puppets etc.

Blue Print for the Leather Industry

The Institute in its endeavour to accelerate the progress of this age-old rural industry has given particular attention to the dissemination of scientific knowledge acquired through research. This is achieved through answering enquiries from industry, publication of process papers and research results in the monthly bulletin and, last but not least, through extension service The Institute sends out teams even to remote village tanning centres to demonstrate new and improved methods. Two Regional Extension Service Centres of the Institute are functioning in Calcutta and Rajkot, four more centres are being set up in Kanpur, Hyderabad, Bombay and Jullundur. The Institute conducts a systematic survey of the problems of the leather industry and undertakes preparation of plans, layouts and blue prints for its development in different states Demonstrations are also arranged periodically in the Institute itself. An 'open house' is arranged in the Institute from time to time.

Training of Personnel

Training of technical personnel at all levels — for industry, for government organizations and for teaching and research — is an integral part of the work of the Institute. To meet this end, the Institute conducts courses for B.Tech. and M.Tech. degree of the Madras University. The Institute has been recognized as a centre of research leading to the Ph.D. degree by many Indian universities. Short-term practical training courses in leathers are organized for the benefit of tanners. A new scheme for exchange of senior technical personnel with those in industry is in operation and this has helped tanners to acquaint themselves with the activities of the Institute and the research workers to become alive to the problems of tanners. In order to stimulate research activities in

the Institute, Guest Professors from different parts of the country and also from abroad are invited for a period of 4 to 6 weeks. Research workers are given facilities for advanced training in foreign countries.

Information and Technical Service

Special courses are arranged for the benefit of foreign trainees. Trainees from Jordan, Nigeria, Iraq, Kenya, Afghanistan and Philippines have already taken advantage of this course. The Institute is now conducting a special course for trainees from Pakistan, Philippines, Thailand, Japan, South Korea and Formosa under the auspices of the Asian Productivity Organization.

Officers of this Institute have been deputed to Afghanistan, Ceylon and Sudan as advisers under the Colombo Plan and the UN Special Funds Projects for the development of leather industry in those countries.

Economics

An economics group has been attached to the Institute in order to.

1) assess the cost of each individual research project

2) evaluate the economic returns of the research results and

3) survey economic problems and marketing problems of the leather industry in general.

This gives a good perspective for the researcher as well as the tanner, so that the research planning is geared to industrial programme for production, for export and the like.

Publication

A monthly journal in English *Leather Science* is brought out for disseminating the results of researches A quarterly in Tamil is also being published and it is proposed to bring out a similar one in Hindi in the near future. Several pamphlets, brochures, process bulletins and proceedings of symposia and seminars have also been brought out.

It is apparent that the present organization of the Institute can render all-round service to the industry, be it technical or economic; and CLRI may justly claim to have created in this age-old industry an awakening to the need and importance of research for improving processes and products, and has thereby contributed to its progress and development.

Classroom experiments

An Apparatus For The Production of Hydrogen Sulphide

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The conventional apparatus for preparing hydrogen sulphide (H_2S) is the Kipp's apparatus. This is rather costly and many schools cannot afford it. In this article an improvised apparatus is suggested. The author claims that this can be made inexpensively, is easy to handle and is as efficient as the Kipp's apparatus.

EDITOR

THE apparatus (Fig. 1) consists of a copper test-tube, 20 cm x 3.8 cm, fitted with a rubber stopper, which carries a gas tap. The test-tube has a few holes in the bottom. It is coated with shellac inside and outside.

First of all fill the test-tube with pieces of flint or glass balls not affected by acid. Fill in the pieces to a height of about 5 cm from the bottom.

Now, on this layer of glass pieces, add requisite pieces of iron sulphide (FeS). Then plug the mouth of test-tube with rubber stopper. Make sure that it is absolutely air-tight.

Next fill a wide-mouthed porcelain jar with dilute sulphuric acid. Cover the mouth of this jar with a lead plate. This plate should have a hole big enough to allow the test-tube to pass.

How to Use the Apparatus

When you want the gas, put the test-tube into the acid in the jar and open the tap. The acid rushes in, comes in contact with the iron sulphide pieces and the reaction starts, producing H_2S. This can then be led into test tubes by a delivery tube, as is done in Kipp's apparatus.

If you shut off the gas by closing the tap, the pressure of the gas which still continues to be produced, forces the acid out of the tube through the bottom holes and the iron sulphide pieces no longer remain covered with the acid. Consequently, the reaction slowly stops The test-tube is still full of the gas. If you want gas again, open the tap. The stored gas will first be available; then more gas will be supplied by the same reaction as stated above.

When the apparatus is not in use take out the test tube, drain out the inner acid and keep it dipped in water so as to prevent rusting of the iron sulphide pieces.

Advantages Over Kipp's Apparatus

At present Kipp's apparatus is generally used for generating H_2S gas. The apparatus described above has many advantages over Kipp's apparatus.

1. Its cost is extremely low in comparison.

2. There is practically no fear of breakage and once the apparatus is set up it will last for years The copper test-tube, being coated either with shellac or lead, does not get spoilt. The strong chinaware jar does not break easily.

3. It is as efficient as Kipp's apparatus. It can give a current of gas continuously for 15 minutes at a stretch.

4. A breakdown can be easily remedied. If there is a failure of the gas supply, it can only be due to three causes·

(a) In case the gas is drawn for a long time continuously, the strength of acid inside the tube probably falls. The remedy is to open the tap, lift the test-tube out for a few seconds and replace it. There will be a fresh supply of acid and the gas current will start afresh.

(b) If iron sulphide (FeS) pieces are used up, which will be evident if remedy (a) fails, then you have only to open the rubber stopper, add a few pieces of iron sulphide to the test tube and replace it in position.

(c) If the stock solution weakens you have to remove the test tube, add some strong acid to the jar and replace the tube.

In the case of the Kipp's apparatus under any of the above three cases, the whole apparatus has to be dismantled. This becomes a job in itself, and you have to wait for a long time to get a fresh supply of gas again The danger of breakage is inherent in this operation

5. In Kipp's apparatus, when the iron sulphide pieces become smaller, they have to be discarded but here every bit of iron sulphide can be used. Only very small particles escape through the holes

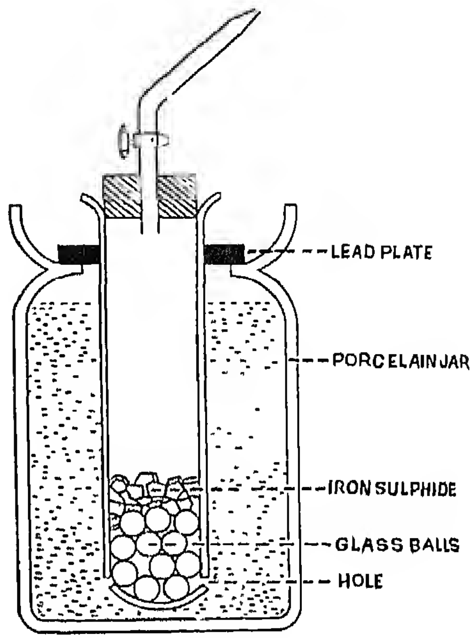

Fig 1 H_2S *Apparatus*

This apparatus is thus better than Kipp's apparatus in all respects. In this apparatus we can increase the gas pressure to any extent. This depends upon the length of the tube, the height of the acid vessel and the position of the iron sulphide pieces in the tube. The present dimensions have been so adjusted that when the gas is released it will enter the test tube at a low pressure so as to avoid spurting out of the solution from the test tube—an accident that generally happens in Kipp's apparatus. The difference in the levels of acid in and outside the tube is kept at about 14 cm. The dimensions as well as the

number of the bottom holes also plays a part in developing the gas pressure This is more or less a matter of experimental adjustments rather than one of mathematical calculation The working principle remaining unchanged, modifications in the dimensions of the different parts and in the quantities of the material used in this apparatus can be introduced by science teachers if they desire to make such an apparatus for use in their schools.

Make Your Own Paper!

M. K. Kapur

YOU can make paper at home or in your classroom exactly in the same way as it is manufactured in the paper mills. Of course it would not possess the quality or smoothness of the paper on which this journal is printed But it would be your paper!

Newsprint and cheaper grades of paper for other purposes are made from wood, cotton rags, straw and similar materials. You can make your paper from old newspaper much in the same way as is done in a paper mill. All you need are the following: four full sheets of newspaper, water, a little kraft paper, bleaching powder, a large pan, an egg beater, soap powder, an ordinary glass window pane, paper towels, sink, cooking pan, laundry starch, flat iron and hot water

Take four full sheets of newspaper and cut or tear them into pieces as tiny as you can and put these in a pot. Add some water so that these bits become pulpy. With the help of an egg beater beat the paper pulp until the pieces are well broken up. Add to this pulp a little paper from a paper bag, to give it strength. The mixture should be a thin paste. Add to this a couple of spoonfuls of soap powder and boil it until it is soft and all the ink is removed. The ink will float and may be skimmed off. If some of the ink sticks to the sides of the pan, it must be removed later Cool the mixture and save out a small sample. Add one or two tablespoonfuls of bleaching powder to what is left. Keep it for half an hour to give the powder a chance to act. Now compare the bleached paper with the unbleached sample which you saved, and see the difference! Pour the paper mixture into about 6 to 7 litres of water in a large pan so that it becomes a diluted mixture. Stir this mixture well.

For making your paper glossy and more tough you have to add a binding agent or size it. For this, put a teaspoonful of laundry starch in a little water, to make a paste. Add a couple of glasses of hot water and boil until the mixture becomes clear. Add a glass of this mixture to the diluted paper mixture which you made earlier. This starch will harden the paper when it is ironed at a later stage. This is called calendering. This also holds together the paper fibres more firmly, makes it glossy and holds ink better.

Put a board across the sink. Place the glass window pane over that board. Pour the diluted paper mixture over the glass pan carefully and spread it as evenly as possible, so that the layer is of uniform thickness. Let it drain as much as it will. Place a piece of paper towel over the layer. Press it down gently but firmly to squeeze out water. Put another dry paper towel on top of it. Roll these layers and lift them carefully from the glass pane. The new sheet of paper will stick to the paper towel. Paper manufacturers call this process 'couching'

Transfer these sheets to the table keeping the paper towels below and the newspaper sheet above. Take another piece of paper towel, place it on the top of news paper sheet. Press a warm flat iron on it for sometime. This will dry the paper and make it glossy. To dry the paper further, take a cooking pan and put the paper sheet over it. Place all this in the oven. You have to be alert and look at the paper from time to time to check so that it is not getting scorched. This process is called calendering and in the paper mills, the paper sheets are passed between hot rollers called calenders. You can give a finish to your new paper by trimming the ragged edges so that they run straight and even and make your paper look like a paper-sheet.

In a paper mill these very processes are carried out continuously on a large scale. The pulp, properly bleached and sized is poured upon one end of a moving screen, made of wire cloth. This screen acts as a filter and allows the water to drain through it. Thus the paper (cellulose fibres) is left enmashed in the form of a wet, thick sheet of raw paper. When the screen moves along, water drips off and the felted mat of fibres becomes sufficiently strong to be couched off. At the other end of the screen this sheet is fed into two large cylinders and the water is squeezed out. The paper is finally dried and calendered by passing it between cylinders which are heated inside by steam. Finally the paper is wound on a reel.

For producing paper with certain special properties, different substances such as clay, rosin, dextrin, aluminium silicate, glue, alum, barium sulphate and pigments or dyes are added to the pulp. The materials to be added depend upon the desired colour, degree of opacity, texture and weight. For example, rosin is added to make the paper resistant to ink and to prevent spreading. Starch, glue, dextrin and similar materials are used to fill up the spaces between the paper fibres during sizing and to give a smooth finish.

Science abroad

Biology Teaching in West African Schools

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IN the continent of Africa and in the English speaking countries of Asia, school education was basically founded on one of the English Universities' system of teaching. In fact, a large number of institutions still offer London Matriculation or Senior and Junior Cambridge Certificates. The Higher School Certificate or Secondary School Certificate was also based on the English pattern.

This system envisaged tropical countries to be extension of and similar to England in all aspects and for a long time did not take note of peculiar conditions that are set by differences in climatic, social, economic and other patterns of those lands. The students after education were fitted into the clerical or other cadres of services that were available to natives of these countries to help their superior officers in running the Government and to further the interests of their colonial masters. For the same reasons other professions were poorly paid.

Scientific and other technical departments were established only recently and these were staffed mainly from overseas personnel and graduates trained in overseas institutions; again along foreign lines, with foreign interests in view. Legal and business professions were the most lucrative Civil and administrative services were the next best

As a result of the rapid development of science and technology in countries of Africa and Asia between the two World Wars it was felt that the English pattern of education in science teaching was deficient in many ways. Attempts were made more than once to revise the curriculum to suit local or regional conditions. These changes did not meet much of the needs of the countries concerned, but only voiced the new thinking in scientific development in England or other European countries. In French speaking areas there were slight differences, but these again were suited to the French conditions. The powerful ORSTOM system developed by French educational institutions, however, helped greatly in the training of local personnel, but to a limited extent and relatively at lower levels

Paper presented at the Symposium on 'School Science Teaching and Curriculum Revision' organised by the West African Science Association in Freetown, Sierra Leone, in April, 1965.

There was not much difficulty in physical sciences but the contents of biological and social sciences were far apart from those obtained in English pattern of school education. The opening of universities of Bombay, Madras and Calcutta in the middle of the last century in India did bring to light the unrealistic approach in school and university education But nothing much was done in the field of biology—that was often considered as two separate branches—botany and zoology—even at the school stage. Most of the types of plants and animals for students in Asia and Africa were common with England and the theme of study was largely morphological or evolutionary in concept. The structure, rather than function, and behaviour rather than physiological aspects of examples selected to illustrate evolution, were given prominence both in school and in university education

While India has discontinued much of the London and Cambridge patterns of education, Africa will follow it at least up till 1967. The Indian system of secondary school, however, is not much different from the English pattern and is thus of limited value, with the result that it produces thousands of high school leavers that cannot find suitable jobs or fit into the newly emerging society in Asia.

The position about Africa in this respect is much the same, if not worse. It is, therefore, highly necessary that new curriculum for school education be developed for developing countries of West Africa and the symposium of the West African Science Association is highly opportune. Firstly, because, this conference will be discussing the theme of National Resources Development in Africa in which field UNESCO/ECA Lagos Conference has recently made notable recommendations. Secondly, we have got before us recommendations of the Tananarive and Addis Ababa conferences of UNESCO/ECA on school and higher education development in Africa. These conferences were attended by accredited members, including some ministers and secretaries of education from African countries and action on those recommendations should be taken up without much difficulty.

In Ghana, we have recently examined the 'A' level syllabus of biology in schools on behalf of West African Examinations Council, and as a member of the Working Party, I am in a position to make known the Ghana view in this respect.

Biology in the Old Syllabus

As already mentioned, school biology course in Ghana was in common with London and/or Cambridge systems. This was based primarily on morphological and/or evolutionary concept of T. H. Huxley and other great biologists of the early 20th century. On account of these, the biology syllabus for school and also for university comprised of bits of almost everything, without any emphasis on a single theme. It provided a general grounding in biology. But most of the concepts have now become obsolete or no longer useful in the present context of scientific thinking in developing countries. The

school curriculum lays an unduly great emphasis on histology, anatomy, morphology, evolution, etc. Lower plants and such subjects like organisation and evolution of vegetative and reproductive organs, etc. are given a great deal of time in the school as well as university curricula.

In the old syllabus, field work was hardly included. Ecology and physiology were relegated to the relatively unimportant position in the course, with the result that students had no appreciation of the question of plants as producers of energy or as natural resources. Similar treatment was given to the zoological portion of the course in biology.

From every point of view, a course like this in biology was considered to be quite out of date and out of time with modern needs of education in developing countries of Africa and Asia

New Thinking in Biological Research and Teaching

From the old evolutionary concept, biology today has risen into two distinct, though related, branches The molecular and biochemical concepts treat organisms as biochemical system and cellular unit as a molecular phenomenon. The phase contrast and electron microscopes have helped biologists to understand biophysical nature of living things. Cell biology has emerged as an important new branch and is bound to make immense contribution in growth of tissues and cells.

Biochemical research has greatly helped to understand the phenomenon of nutrition and growth. Much of industrial applications in biology stem from biochemical studies. These have also helped to control disease by the application of insecticides and fungicides. Hormones, vitamins and antibiotics are extremely important new developments in biology that must be given a due emphasis in any teaching programme. These, however, demand a great deal of knowledge of chemistry, physics and biology that are supporting sciences for a successful programme of teaching and research in biochemistry and biophysics and must, as a rule, be included in curriculum of university education at a postgraduate level. The final year of the graduate course could, perhaps, be utilised for this aspect of biology.

For school syllabus, ecological and environmental aspects of living organisms are the most appropriate for developing countries. New approaches in ecology envisage ecosystem as a workable unit in which the plant is taken as a primary producer of energy. The animal is secondary producer and the whole pyramid of life has man at its head The proper understanding of energy chains and food chains in the ecosystem are necessary to be included in a school curriculum. These are not new lines of thinking but their inclusion in school education has been considered to be of importance only recently for developing countries.

New thinking in biological research, therefore, requires that school curriculum should include consideration of biochemical and ecological aspects

and evolutionary aspects be given only a passing mention

Applied Biology

Agriculture, forestry, epidemiology fermentation and industrial preservation, etc., are all problems of applied biology, concerned in the production of food for human beings. Economic botany concerns itself with plants that are of known use, and economic zoology finds application in the development of fisheries, animal husbandry, wild-game conservation, etc. Both parts of biology are concerned in fields of soil and water conservation and the proper development of the habitat. Industrial developments that involve the disposal of waste products in air or water are also problems. The changes in the rural landscape due to urbanization, industrialization, horticulture, town planning, monoculture, mechanization of agriculture, all change to a great extent the position ecosystem and these must be considered as problems of applied biology. For developing countries that have not yet attained self-sufficiency in food production and are on the way to industrialization, applied biology is of the greatest importance and must be included in the school syllabus in Africa.

Applied Biology and Natural Resources Development

Applied Biology is greatly concerned in the development programme of resources, especially of organic origin. Plants and animals are primary and secondary producers of energy respectively, and training and research programmes in the increased production of the ecosystem are biological problems. Problems of Man and his relationship with other natural resources in the ecosystem cannot be tackled at the university and later, if a thorough grounding is not done at school stage in biological fields.

GHANA SYLLABUS FOR SCHOOLS

Based on the concepts mentioned above and the needs of the developing countries, it was considered that the new school syllabus at 'A' level G.C.E. be orientated towards ecological and environmental aspects of biology. The Ghana Working Party formed by the West African Examinations Council, with members drawn up from the three universities, representatives from Teachers' Association, British Council, etc., discussed this question at great length. Professor Ewer of the University of Ghana, and Mr. Hall of the University College of Cape Coast and the author of this article were the exponents of the ecological concept and the syllabus now prepared is based on this. I may quote here from the introductory note below:

'The biological problems of West Africa are dominantly ecological. Ecology is not only the central theme of much research but it is the core of many socio-biological questions of the utmost significance The present syllabus therefore lays major emphasis upon the relations of organisms to their environment, upon current ecological concepts and methods, and upon the biological relations of man. At the same time it is so constructed as to give full scope to

a presentation within this framework of physiological, biochemical and molecular aspects of biology.'

'An analysis will show that the material covered, apart from a greater emphasis upon ecological ideas and methods, is very similar to that of the 1967 University of Cambridge Examinations Syndicate syllabus for Higher School Certificate Biology. It differs markedly from the University of London Advanced Level biology syllabus which is mainly based upon T. H. Huxley's type system and in which ecology and ecological concepts receive no recognition beyond a sentiment that field studies afford a training in accurate and intelligent observation.'

'In the present syllabus, with the exception of an initial study of a flowering plant and a mammal, no further types are specified for study. It is considered that it is more valuable for a pupil to come to a comprehension of the classificatory system upon the basis of a study of material he or she has collected, than from an examination of single representatives of particular organisational forms, a method of study which allows no real assessment either of variation within a taxon or of those features which happen to be peculiarities of the type.'

The main headings of the syllabus are given below:

A. Organisms and Energy

1. *The ultimate source of energy. The energy inter-relations between plants and animals.*

   Sources of energy in the environment. The energy-flow between organisms. Holophytic and holozoic nutrition. Primary and secondary producers. Food webs. The pyramid of numbers. Water, carbon, nitrogen and oxygen cycles.

2. *A flowering plant as an example of a primary producer*

   (a) The fact that plants are composed of cells. An elementary study of the chief chemical constituents of cells to permit an understanding of physiological processes — salts, carbohydrates, amino acids proteins and fats. Rates of chemical change, catalysts and enzymes. The general structure of plant cells—cytoplasm, mitochondria, ribosomes, chloroplasts, cell membranes, the nucleus and non-living cell inclusions.

   (c) The biochemical nature of photosynthesis and respiration. Inorganic nutrition.

3. *A herbivorous mammal as an example of secondary producer.*

B. The Diversity of Organisms

1. *Micro-organisms*

   Protista (Protozoa and unicellular plants), bacteria, viruses (including the bacteriophages).

2. *Plants*

Algae	— Unicellular and filamentous types
Fungi	— Parasitic and saprophytic forms and yeast.
Bryophyta	— Liverworts and mosses
Ferns	—
Angiosperms	—

3. *Animals*

A study of the characteristics of the following phyla and their major classes:

Coelenterata
Platyhelminthes
Nematoda
Annelida
Mollusca
Arthropoda
Chordata

4 *Classification*

The principles of classification illustrated by reference to the above groupings, the concept of species.

C. The Organism in its Environment

1. A comparison of the seas, the freshwaters and the land. The special problems of freshwater as an environment including osmotic regulations. The special problems of land as an environment including a study of reproductive adaptations in plants and animals, as well as problems of obtaining and retaining water.

2 Environmental factors affecting photosynthesis and transpiration in plants Particular problems posed by dry tropical environments and by saline soils and habitats, the effect of environmental factors including photoperiod on plant reproduction, growth and form.

3 The concept of homoeostasis in animals illustrated by thermoregulation and water balance in mammals. The particular problems posed by both humid and arid tropical environments and their solutions by the organisms should be considered.

D. Types of Habitat and Their Communities.

1. A study of a variety of habitats, their fauna and flora including desert, forest, freshwater and sea. The biological inter-relations of plants and animals within such habitats including examples of commensalism, symbiosis, saprophytism, parasitism. Social inter-relations between animals including the role of sign stimuli in such relations. The physical and chemical features of these habitats, their measurement and their reflection in the characteristics of the fauna and flora which occur. A practical know-

ledge of at least two such major communities, including one aquatic environment is required. The importance and significance of sign stimuli can be illustrated by any of the classical ethological studies such as the beak responses of young herring gulls. Social behaviour and its complexity can be illustrated and studied in bees.

2. *The Soil*

A study of soil as biological systems and their influence upon the flora, including a knowledge of methods of sampling soil communities and of determining the physical and chemical properties of different soils.

3. *The Ecosystem and its Dynamics*

The concept of ecosystem. Productivity and its estimation. Population dynamics including methods of estimation of population. Natality rates, mortality rates, age distribution, population growth, population fluctuations. Competition dispersals and migrations. Seasonal changes. Succession.

4. *Distribution*

Factors affecting distribution. Limiting factors. The concept of autecology. Microhabitats. The importance of habitat selection in determining animal distribution. Elementary behaviours patterns, taxes and kineses.

E. **The Origin of Diversity, Heredity and Evolution**

1. *Heredity*

2. *The source of variation.* Evolution by natural selection.

3. *The evidence of evolution and natural selection.*

F. **Man and his Biological Environment**

1. *Man and his biological productivity.*

Human populations: their numbers, age structures and rates of increase in relation to food resources.

2. *The biological consequences of agriculture*

The ecological effects of agriculture. Monoculture and the spread of plant diseases and pests. The principles of plant protection; chemical, biological and genetical control. The effects of herbicides and pesticides on primary and secondary production and on land and in water. Deforestation, overcropping, overgrazing and their ecological consequences such as soil erosion.

3. *The biological consequences of urbanization and industrialization.*

The ecological effects of population concentration. Pollution of water and air, its control including the treatment of sewage. The spread of microbial and parasitic diseases. The control of parasitic diseases including the control of vectors. The creation of new habitats such as man-made lakes.

Attention should be paid to the control of the following diseases by means of their vectors: malaria, sleeping sickness, schistosomiasis and river blindness. A knowledge of the life cycles of both parasites and vectors is required.

4. *Conservation*

Conservation of resources: water, soil, forest, wild life, fisheries. Forest reserves, game reserves and national parks.

SUMMARY AND CONCLUSION

The present day problems of Africa demand a new approach to the school education in biological studies. Firstly the Natural Resources Development Programme that is geared to development and industrialization cannot be achieved without a proper training and research in applied biological fields. Secondly, Africa has a tropical climate; soils, vegetation and animals and their well-being is very much related to the environmental features.

The new syllabus in biology for schools that has been recently prepared by the Working Party in Ghana has put due emphasis on ecological and environmental aspects of biology The molecular and biochemical aspects have also been considered but the old morphological and evolutionary concepts in biology have been largely discarded having become out of date and obsolete. Parts of the syllabus given in the paper emphasise plants and animals as primary and secondary producers of energy.

Young folks corner

Sir Ashutosh Mukerji – A Tribute

N. R. Dhar

Sheila Dhar Institute of Soil Science

The birth centenary of Sir Ashutosh Mukerji (1864–1924), a great educationist of India who did yeoman service to the cause of higher science education in this country, was celebrated only recently. At a time when most senior posts in colleges and universities, as in other spheres, were held by Englishmen, Sir Ashutosh appointed Indians to the chairs of science in Calcutta University. This bold step marked a turning point in the Indianization of science in India.

EDITOR

SIR Ashutosh Mukerji succeeded Sir Alexander Pedlar as the Vice-Chancellor of Calcutta University in 1906. This post he occupied till 1914, and again in 1922. As a young man, Sir Ashutosh had done some excellent research in mathematics. He had plenty of drive, energy and initiative and converted Calcutta University from an examining body into a teaching and research institute. At first, he created professorships in humanities and organized instruction in Sanskrit, philosophy, political science and other subjects. But he realized that for the development of India, study and research in pure and applied sciences were essential and these had to be organized. With generous donations from Sir T. N. Palit, Sir R. B. Ghose, the Raja of Kaira and others, he created professorships in physics (pure and applied), chemistry (pure and applied) botany, zoology and agriculture. He also built up suitable laboratories for these sciences.

During the British rule, the introduction of the clause that 'none but Indians should hold the chairs,' in the bye-laws of the College of Science required foresight, imagination and strength of character. These precisely were the main characteristics of Sir Ashutosh. In contrast to this, the Indian Institute of Science at Bangalore, which had been established ten years earlier through the munificence of Sir Jamshedji Tata, was staffed by Englishmen.

A group of British educationists in the Indian Educational Service, notably H. R. James, W. A. Archbold and Dr. E. R. Watson among others, were opposed to this move of Sir Ashutosh Mukerji in the Senate of Calcutta University. Dr. Watson, a very capable

chemist and an eminent research worker, moved a resolution to the effect that 'The Senate views with alarm the rapid increase of passes in the Calcutta University examinations.' But Sir Ashutosh Mukerji, with great force of character, fought these obstacles very successfully and brought education in science to the door of every citizen of India

In May 1924, the Government of India organized the first Congress of Indian Universities at Simla. Delegates from various universities in the country participated in this Congress which discussed measures to improve the universities. Sir Ashutosh Mukerji was appointed by Calcutta University to lead its delegation. But all the delegates were shocked to learn that he had passed away at Patna and could not join the delegation. A deep sense of sorrow and loss was visible on the faces of all delegates.

While paying our homage to the memory of Sir Ashutosh Mukerji during the centenary celebration we must also remember the other great Indian pioneers of science like Acharya J. C. Bose, Acharya P. C. Ray, Sir C. V. Raman and Sir Jamshedji Tata.

Oil and its Story

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HAVE you ever stood near India Gate on a busy evening and watched the flow of traffic round the 'island'? Cars, buses, scooters and taxis rush past you in a frenzy of speed. Overhead you might see a silvery jet streak across the sky and within seconds disappear from sight. What is the motive power behind all this speed? Every car, bus or scooter that you see goes some time or the other to a petrol station and gets its tank filled with oil. The engines in these vehicles run on petrol and motor oil, while the wheels and other parts require grease. A jet plane flies on jet fuel while propeller planes use aviation gasoline and rockets use fuels consisting partly of petroleum. The diesel engines in locomotives, trucks, tractors, ships and boats all run on diesel oil. Oil therefore is really the power behind all the speed you see.

As you stand near India Gate, you might also see, now and then, an old-fashioned cart drawn by men, with a lamp swinging from its creaking frame. This lamp burns kerosene oil. So even this slow outmoded cart also depends on oil to light its way.

All these fuels and oils come from petroleum from which we also get other products like wax, the asphalt used on roads, fuel oil and the gas you get in cylinders. Petroleum is a mineral found deep in the earth in the form of a thick fluid which may be dark or light coloured. This fluid is usually called

Fig. 1

crude oil. Now how did this oil come to be in the oil wells?

How Oil was Formed

If you want to know the how and when of the story of petroleum, you will have to go back more than a million years, perhaps several million years. Some scientists would like to take you back more than 100 million years.

At that time the earth was a bare strange looking place. Most of the land was covered with water. The exposed land itself had many active volcanoes. There were no trees, no bushes, and no people. No animal lived on the land.

But in the water along the shores, the story was different. Billions and billions of tiny animals and plants lived in these waters (Fig. 1). They were short-lived and when they died their bodies sank into the mud on the sea bottom. As years passed, more mud from the rivers flowed into the sea and settled on top of these alongwith the dead bodies of animals and plants got squeezed more tightly, and gradually the layer changed into rock.

The layers of rocks so formed also underwent many changes due to pressure, heat and earthquakes. In some places the rock layers were pushed above the level of the sea. They became dry land.

A long time afterwards, perhaps millions of years later, the rock layers again sank below the sea. Once again

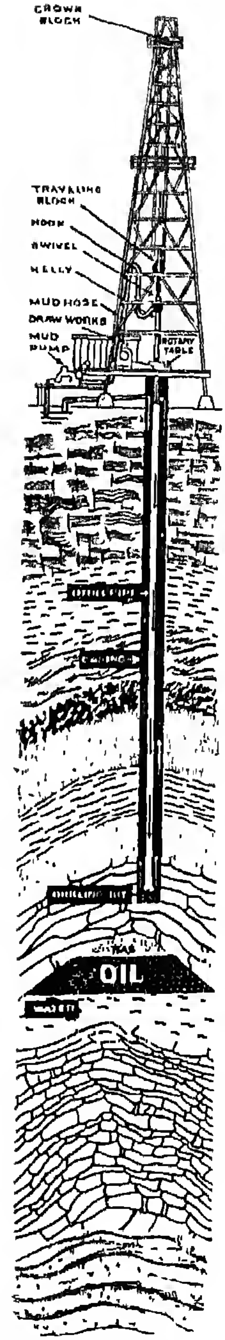


Fig. 2.

rivers carried sand, pebbles and dust into the sea, which settled on the original rock. Layers after layers of dead animals and plants were thus mixed with mud and sand and were squeezed together to form layers of rock Parts of the earth rose above the water and sank again many times.

Birth of an Oil Field

Gradually, over millions and millions of years amazing things happened. The bits of dead animals and plants in the rock were heated and squeezed till they changed into drops of oil The same process that produced oil also produced natural gas. Thus oil and natural gas are often found together.

The oil and gas collected in tiny spaces or pores of certain kind of rocks. These were porous rocks such as sandstone Drops of oil were held in the pores much as water is held in a sponge.

Here and there on the earth a layer of the oil seeped up to the surface through cracks in the rocks. Sometimes it formed a scum on the top in springs and ponds. In some places it hardened into a tarry substance.

Early Uses of Oil

Man is believed to have appeared on the earth about a little more than one million years ago. Perhaps it did not take him long to discover the oil on the surface According to the Bible, Noah used pitch to seal the seams of the Ark he was building. This pitch was a kind of asphalt formed from oil seepings that had thickened and hardened.

The early Babylonians used asphalt to pave their roads. The Egyptians burnt oil in lamps and in those days only the wealthy could burn oil lamps. The Romans named the oil patroleum, meaning rock oil.

First Refinery

Man began to experiment with this rock oil. He began to distil the oil in iron pots with a spout at the side. He got first a straw-coloured oil which burnt in a special lamp that he invented. The equipment he used was called a still because it separated the kerosene from the crude oil by the process of distillation. Kier was the first man to try refining oil in this way. Slowly others built better stills and produced more oil.

Science notes

WHAT WILL LIFE BE LIKE IN 1984?

During 1964, the British journal *New Scientist* ran a long and remarkable series called 'The World in 1984,' in which outstanding scientists, engineers, sociologists and others were asked to peer 20 years into the future

The articles have now been collected in two volumes and published as paperbacks The first looks forward mainly in terms of pure science and technology, while the second contains articles with a more sociological slant.

JOHN DAVY, science writer of the London Sunday newspaper, *The Observer*, here analyses in two reviews the most important trends that emerge from reading the predictions of experts about the way the world is developing.

GEORGE ORWELL'S novel '1984' was a totalitarian nightmare. The most striking thing about the *New Scientist* series is the virtual absence of pessimism or sense of crisis with one or two notable exceptions. The general mood is of careful optimism.

An odd-man-out is the distinguished theoretical physicist, Professor Abdus Salam, who writes not about physics but about the less developed parts of the world.

In 20 years' time, he says, these areas will still be as hungry and as desperately poor as they are today. He sees no sign of the passionate social awakening to these problems which he believes is necessary if they are to be solved. In the next 20 years, he hopes, a crusade against poverty 'will come to be preached with the fury it deserves within the poorer countries'.

He continues soberly: 'I can only hope it remains inward turning—that it does not become a destructive wave of antagonism against those fortunate few among the nations of the world who somehow inherited most of the Earth's resources and do not quite need them all'.

Warning of quite another kind comes from Professor Joshua Lederberg of Stanford University in California. He is concerned with the social and ethical dilemmas which advances in biology may bring. For example, it may become possible to transplant vital organs quite freely—even hearts and livers—long before the moral and economic problems of organizing 'market' for human spare parts have been tackled.

Medicine may also bring considerable prolongation of life with full retention of strength and faculties. This will make nonsense of present social arrangements for education, retirement, and much else.

Furthermore, it may become possible to enhance intelligence or other faculties by treatment of the unborn child,

From SPECTRUM, May 12, 1965

to decide sex, or produce identical twins at will.

Most far-reaching of all, transplantation of ova and storage of semen would mean that one mother or one father could in principle pass on their hereditary characteristics to any number of children—making the whole question of eugenics an immediate social issue.

Professor Lederberg says he has been accused of 'demonic advocacy' for discussing these possibilities and 'not pretending they are far off'. But he points out that such discoveries may emerge from research on entirely humanitarian problems such as treatment and care of the aged, mental retardation in children, and help for infertile couples.

Perhaps the outstanding optimist of the series is Dr. Wernher von Braun, the rocket engineer, who believes that space exploration will help to unite men and release energies which might otherwise be channelled into war—'just as the Crusades saved Europe much bloodshed by diverting the energies of its fighting men to a far away objective'.

By 1984, he says, men may have landed on the surface of Mars; they will certainly have flown past the surface both of Mars and of Venus to have a close look. Meanwhile, he predicts, there may be a large permanent astronomical observatory on the Moon, to which crews and scientists will be shuttling as a matter of routine.

Other contributors, too, foresee much new astronomy being carried on outside the Earth's obscuring atmosphere, and Professor Fred Hoyle predicts that study of the most distant reaches of space may produce a revolution in terrestrial physics.

He points out that although much is now known about the fundamental particles of nature and the forces which act between them, the actual magnitudes of these forces and the masses of the particles are not explained. Indeed, says Hoyle, physics is still 'appallingly ugly', full of 'strange numerical values' which are unexplained

This may be because the physicist has assumed that the forces he is dealing with can be explained 'locally',—and that they do not change with time. But astronomy may show, Hoyle says, that forces observed in the laboratory are in fact affected by 'long-range couplings' with the rest of the universe—and that quantities regarded as 'constant' are actually changing very slowly with time.

Thus astronomy could be 'midwife' to a major revolution in physics by 1984.

Closer to home, several authors emphasize the importance of caring for the Earth's natural resources—minerals, soil, water, air. Water, in particular, will need to be most carefully husbanded. Consumption is soaring in advanced countries and less developed countries need much expanded supplies, not only for hygiene and better living standards, but for irrigation.

According to M. Pierre Laffitte, of Paris, the world's water supplies will have to be doubled by 1984, and the

cost may be a staggering £1,000,000,000,000.

In the cities, some of the most profound changes will have been brought about by computers and advanced communications. Sir Gerald Barry of Britain's Granada Television foresees people 'dialling' their favourite newspaper, which will come over by private teleprinter. Or they will dial the latest best-seller, a back number of the periodical *Punch*, or a classic film which will automatically be shown on their television screen

Vast amounts of routine drudgery—mainly clerical and machine-minding—will have been taken over by computers. But, as Dr. M. V. Wilkes of Cambridge points out, there could also be hazards. A man speeding along a deserted road at night might receive a printed slip by post the next day saying a fine had been automatically deducted from his account—all done by concealed radar and computer

In America, the tax authorities are busy installing a vast computing system which will make tax-dodging of any kind very difficult—and many branches of life, Dr. Wilkes warns, 'will lend themselves to continuous computer surveillance'. It is here, in fact, that the authors see some real Orwellian possibilities in 1984 (in the novel, the state police had concealed monitors in private homes and everywhere).

There could still be spectacular advances in aviation, according to Dr. M. J. Lighthill, Director of Britain's Royal Aircraft Establishment from 1959 to 1964. For example, it may be possible to develop an aircraft which is 'all wing'. Flying in one direction, its shape would be suitable for low speeds. For high speeds, it would slew round, turning another section of its surface into the air-stream. This would give 'variable geometry' without having the movable folding wings at present proposed for advanced dual purpose aircraft.

Finally, by 1984 Hovercraft may be well-established as a full blooded means of transport. Mr. Christopher Cockerell, the Hovercraft inventor, predicts that hoverferries will be in routine operation across the English Channel and other busy routes, carrying 100 cars and some hundreds of passengers. And by 1984, a really huge trans-oceanic 'hoverliner' — possibly nuclear-powered — may be on the drawing-boards.

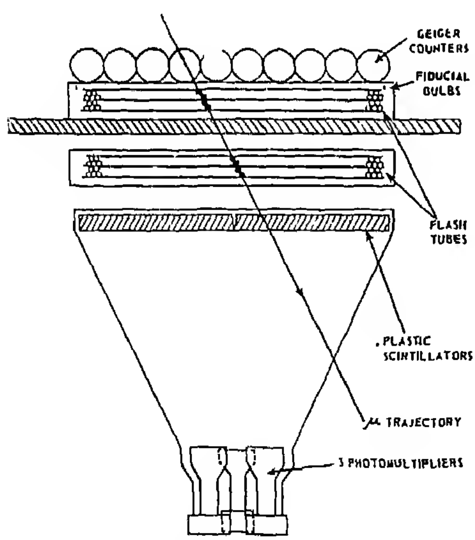
But in 20 years time, the hover principle may also be in use for ultra-fast inter-city transport, in the form of 'hovertrains' running along single concrete tracks Supported on a thin-air cushion, they could attain speeds of 300 knots or higher, using only a fifth of the power needed by an aircraft of the same speed.

Mr. Cockerell concludes by giving an example of what he regards as true '1948 engineering'. Hovertrain tracks, he says, would have to be aligned with great precision. The solution may be to coat them with an inch (2 54 centimetres) of special plastic, and plane them smooth with a special service train at intervals.

Even if only a few of these predictions are realized, they will obviously have far-reaching effects on government, leisure, education, trade and international relations. These are some of the topics treated in volume two of this series, which will be reviewed in a second article.

PARTICLES FROM STARS DEEP DOWN AN INDIAN MINE

Scientists from the University of Durham, England, together with workers from India and Japan, are studying neutrinos—mysterious particles coming from the interior of the stars—8,000 feet (2,450 metres) down in a goldmine in India. The mine is at Kolar and extends 10,000 feet (3,000 metres) below the surface.



EXPERIMENTAL ARRANGEMENT

An Indian team from the Tata Institute in Bombay, is also working in the mine. Results are just beginning to be recorded.

Most of the neutrinos arriving at the earth's surface pass straight through the earth and out the other side. They have no charge and no mass, so that they are extremely difficult to detect. In addition, the earth is constantly bombarded by the so-called cosmic rays, which are charged particles, also arriving from the sun and the stars. They can 'mask' the arrival of neutrinos.

The idea of carrying out detection experiments deep inside in the Earth is to shield them as much as possible from beams of cosmic rays. The deeper the experiments can be placed, the greater the absorption of these interfering particles in the rock.

At Kolar, the scientists have assembled banks of neon flashtubes, and other detecting equipment. When a charged particle passes through a neon tube, the gas becomes electrically conducting and the tube will flash. Lines of light are produced in the banks of tubes corresponding to the track of the particle and these can be recorded on film.

Although neutrinos are not detectable themselves, they do very rarely, hit atomic nuclei and cause charged particles to fly out. A few neutrinos out of the millions and millions passing through will hit nuclei in the surrounding rocks and produce particles which leave their 'fingerprints' in the flashtubes. And from the angles of the events, the scientists can tell from which direction in space the neutrinos came. One or two events of this type have now been recorded by the team at Kolar.

The present intense scientific interest in neutrinos arises because only they can escape from the interior of stars, so they may be able to give information that no other means can supply Everything we know about stars, so far, is related to their surfaces.

Eventually, the scientists hope to take their experiments down to the bottom of the Kolar mine. Only one mine in the world — in South Africa — is deeper than this. Ten thousand feet (3,00 metres) down at Kolar the air temperature is 130°F. (54° C.) and the rocks are at 150° F. (66° C) — too hot to hold.

ROY HERBERT

(From SPECTRUM June 13, 1965)

SCIENTISTS COMBINE TO STUDY WORLD'S NATURAL RESOURCES

Biological Programme

Scientists the world over are engaged in a enormous research project which is just beginning and in which international collaboration is both willing and smooth. It is the International Biological Programme (IBP), concerned with 'the biological basis of productivity and human welfare'

The objective is to ensure a world-wide study of (a) organic production on the land, in fresh waters and in the seas, and the potentialities and uses of new as well as of existing natural resources; and (b) human adaptability to changing conditions.

This is nothing less than the future of mankind. It means the systematic study — for the first time on such a scale — of the natural resources of the earth and a fresh, thoroughly organized look at how human beings develop to meet changes in environment, which nowadays may be rapid

Under the IBP, teams will be working in all conditions from deserts to polar ice, on water and land, on crops and bacteria, on food intake and colour vision. Information from this immense effort will be shared between the countries taking part for the good of all of them.

Ambitious as it is, the IBP needs a lot of preliminary arrangement. The money for it, which will eventually run to millions of pounds, is coming from the participating governments, but the organization is independent of them.

Headquarters for the IBP have been set up in London in offices provided by the British Government and the Royal Society, which has now published details of the British contribution and its place in the general picture.

Five-year Programme

Most of the time from now until 1967 will be occupied by what the IBP organizers call Phase 1, which is mainly the design of research work and studies of its feasibility. In 1967 the programme will get properly under way (Phase 2); at the moment it is expected to last about five years.

Because of the large selection of subjects, the IBP had to be split into several sections. The first three of

these are concerned with the productivity of land, fresh water, and the sea. Out of these came other obvious topics — conservation of terrestrial communities, production processes (such as photosynthesis, the still mysterious process by which plants use light to grow), and the use and management of biological resources. The seventh and last section is concerned with human adaptability, which includes physiology, anthropology, sociology, and so on.

Under the British part of the programme leading up to the IBP proper, practical work has already begun Survey teams have been out to the desert lands of Jordan As a direct result, a national park has been set up and Jordan will establish in it an institute for biological investigation of desert and oasis conditions.

Big Artificial Lake

On the river Niger, where a 500-square-mile lake will be formed by damming at Kainji, university scientists —alongwith Nigerian colleagues—are studying the influence of the forthcoming change on the biology of the area They have now been joined by American and African sociologists who are looking at the problem of the people living on land which will eventually be under water.

Later, bases will be set up in savannah country in Uganda and in tropical rain-forest. Here productivity will be studied in depth—production of trees, shrubs, grasses and herbs, how they are used by mammals and insects, the activities of predators and parasites, and how all these things dovetail together.

These are only examples from the British contribution to the IBP, which has about a hundred items. They can, of course, be matched by similar ones from the programmes of the other countries, of which there may be about 50 collaborating.

Need to Expand Resources

Basic to all the work is a concern for fundamental research Applied science has made such strides in many areas of biological production—in agriculture and fisheries, for instance—that understanding of the processes involved in productivity has lagged behind

The same thing applies to medicine and social science The IBP is important because we need to expand biological resources urgently to feed the peoples of the world. But it is also important because the world and the conditions of people are changing so fast under the pressure of applied science and technology that many of its present features will soon *vanish*. *Part of the* IBP's *raison d'etre* is to conserve these as long as possible for the benefit of future generations.

At the end of 1972 it should be possible for scientists to take a much more comprehensive view of the teeming living systems of the earth.

There may be no revolutionary discoveries from the IBP, but it will, at the very least, greatly increase our

understanding of the world we live in and so our ability to manage it for the welfare of humanity

Co-operation between nations on topics of such moment is, by its very nature, unspectacular. But in the long run it is more important to the future than many other of man's preoccupations.

By Courtesy: British Information Services (see also *School Science 4* (1)· 1965).

STUDYING THE ULTRA-VIOLET REGION OF THE SPECTRUM

From an experiment conducted by the Space Research Group at University College, London, British scientists expect to add valuable information to their knowledge of the stars. They particularly want to find out more about the very distant stars that exist far out in the ultra-violet region of the spectrum.

This region does not penetrate the atmosphere; therefore, it cannot be studied by scientific astronomy from a ground-base on our planet. A specially-designed telescope, fired by rocket into the zone above the bulk of the atmosphere, was launched on July 14, 1965, from the Woomera Range, South Australia, to get some of the information which the scientists need, and simultaneously to transmit this information back to the ground-station.

The Hottest Stars

One of the scientists' problems is: the hottest stars in this ultra-violet region emit most of their energy in it, which is the reason that astronomers till now have been able to learn very little about the physical processes going on within them. It has long been known that by nuclear processes energy is generated in the interiors of these stars, and that by a very complex system this energy eventually reaches the surface to be radiated as starlight. From the recent Woomera experiment, scientists hope to learn a good deal more about this problem

Incidentally these 'hottest' stars are known to be immensely hotter than the sun, which itself is 5,700°C, on its surface, and is believed to be as much as 14,000,000°C in its interior So, in seeking information about the energy generated from the 'hottest' stars, astronomers are dealing with questions of heat that surpass imagination.

The equipment carried in the 'rocket telescope' is complicated. It comprises three 'photo-multipliers', or extremely sensitive ultra-violet detectors responding to different wavelengths and set at the focus of a large telescope mirror. As it picks up signals from each of the stars coming into the field of view, these are counted and amplified on board the vehicle, while being automatically transmitted to the ground-station *via* telemetry-link.

Series of Investigations

Of course, such signals are only valuable if it is known from which stars they emanate. Therefore, the equipment has to include various devices explaining to the scientists which star

appears in the field of view at any given time. Also, there have to be special detectors, such as moon detectors, referring the telescope axis to the direction of the moon; airglow horizon detectors, to set a bearing on the faint, narrow band of light showing from the well-known 'shell' of glowing air situated at a height of around 100 kilometres; and magnetic sensors referring the vehicle to the direction of the earth's magnetic field. All these devices are included to guard against the possibility of failure, which might invalidate the ultra-violet signals themselves.

At the moment, University College scientists are working on a series of these ultra-violet investigations. They want, as well, to probe the question of intervening dust and gas. What they are really doing is trying to solve a scientific jig-saw which they are gradually assembling by close study of the faint light the stars give us, fitting the pieces of information together as they acquire them.

By Courtesy: British Information Services, New Delhi.

A BREAKTHOUGH IN LOCUST CONTROL IS POSSIBLE

The possibility of a breakthrough in locust control is referred to in an article in the latest issue of *Tropical Science*, the quarterly journal of the Tropical Products Institute, London.

The article says, 'In experiments with North African locusts, two British scientists claim that egg development is controlled by two endocrine glands in the locust's head. By killing one of these glands with chemicals it would be possible to stop the locusts breeding. Since their fast reproduction rate is one of the factors that makes locusts particularly dangerous, this method of limitation could eventually prove to be more effective than the poison sprays now used to kill them.

'One of the two glands controls the manufacture of yolk material for the eggs. The other, known as the *Corpus allatum*, transfers the materials from the blood into the eggs, 'switching' on and off as needed If the *Corpus allatum* could be neutralized by a chemical agent, this would effectively prevent breeding.'

The Next Step

The next step is for the chemist to undertake the task of finding a suitable agent.

New trends in science education

Summer Institutes Programme

The Institutes of 1965

Forty-nine summer institutes for secondary school teachers were organized from April 26 to July 15, 1965 in collaboration with the various universities all over the country, as follows.

Biology: Delhi, Agra, Indore, Jodhpur, Kerala, Madras and Ranchi

Chemistry: Panjab, Allahabad, Lucknow, S V. Vidyapeeth, Rajasthan, Vikram, Nagpur, Osmania, Annamalai, Bangalore, Utkal, Burdwan and Jadavpur

Physics: Panjab, Agra, Gujarat, Saugar, Ajmer, Marathwada, Udaipur, Sri Venkateswara, Andhra, Bangalore, Gauhati, North Bengal and Patna.

Mathematics: Delhi, Kurukshetra, Aligarh, Allahabad, Baroda, Jabalpur, Nagpur, Jodhpur, Andhra, Kerala, Madras, Karnatak, Gauhati, Ranchi, Cuttak, and Burdwan.

Nearly 2,000 secondary school teachers participated in the institutes. Eighty-eight American experts were associated with these summer institutes as members of the academic staff The teacher participants were as usual selected from all over the country, while the American experts were made available by the USAID.

The overall record of the summer institutes for secondary school teachers held during the last three years is given below.

Subject	Year 1963	1964	1965	Total
Biology	1	4	7	12(500)*
Chemistry	1	4	13	19(700)
Mathematics	1	4	16	21(800)
Physics	1	4	13	18(700)

	Biology	Chemistry	Mathematics	Physics
Total number of teachers in the subjects as in 1965	16,000	10,000	25,000	10,000
Percentage of Institute trained teachers as in August, 1965	3 1	7 00	3 2	7.00

*Figures in brackets indicate the number of institute trained teachers

Thus by August 1965, nearly 2,700 secondary school teachers, i.e., about 5 per cent of the total teachers strength of the country, were institute trained and were ready to establish in their own class-rooms and laboratories the 'new approach' to the teaching of their disciplines.

It would be ideal if all the teachers in secondary schools could have the benefit of institute training, but this perhaps may not be feasible at present. Plans are under consideration for expansion of the programme of summer institutes as given in the following table so that it would be possible by August 1971 to have nearly 50 per cent of the total number of secondary school teachers trained through the summer institutes.

PROJECTED PROGRAMME OF SUMMER INSTITUTES FOR SECONDARY SCHOOL TEACHERS – 1966-1971.

Year	*Total teacher strength*	*Percentage of teachers selected for participation*	*Maths.*	*Chem.*	*Phy.*	*Biology*	*Total**
1966	67,000	5 per cent	28 (1,400)	11 (550)	11 (550)	18 (900)	68 (3,400)**
1967	72,000	7.5 per cent	44 (2,200)	18 (900)	18 (900)	28 (1,400)	108 (5,400)
1968	75,000	10 per cent	61 (3,050)	25 (1,250)	25 (1,250)	39 (1,950)	150 (7,500)
1969	79,000	10 per cent	64 (3,200)	27 (1,350)	27 (1,350)	41 (2,050)	159 (7,950)
1970	84,000	10 per cent	67 (3,350)	29 (1,450)	29 (1,450)	43 (2,150)	168 (8,400)
1971	87,000	10 per cent	70 (3,500)	30 (1,500)	30 (1,500)	45 (2,250)	175 (8,750)

*50 participants per institute

**The figures within the brackets indicate the number of participants in the institutes

Position of institute-trained secondary school teacher as in August, 1971.

Mathematics	17,000	49%	of 35,000	teachers.
Chemistry	7,000	47%	of 15,000	teachers.
Physics	7,000	47%	of 15,000	teachers.
Biology	11,000	50%	of 22,000	teachers.

News and notes

SCIENCE AND MATHEMATICS TEACHING PROJECT UNDER THE UNESCO TECHNICAL ASSISTANCE PROGRAMME

In close consultation with the Unesco Experts working in the Department, four different teams are working to develop a syllabus for teaching the Sciences as independent disciplines of physics, chemistry, biology and mathematics in class VI and chemistry in class VII. The syllabus for each subject has been finalized for the middle and secondary stages. At present the work on class VI is in progress. The teaching materials and teacher guides have been prepared in each subject in order to guide teachers as regards demonstrations, student activities, etc. When the manuscripts for all these subjects are ready, they will be translated into Hindi and printed for use in the schools in an experimental project.

The Department with the cooperation of the Directorate of Education is trying out this syllabus in 12 schools in Delhi as an experimental project. The teachers of the three subjects — physics, biology and mathematics in each school were brought together in an Orientation Seminar at the Government Higher Secondary School, Alipur Road, Delhi, on September 23 and 24, 1965. The conference was addressed by Dr. D. S. Kothari, Chairman, University Grants Commission and Shri L. S. Chandrakant, Joint Director, National Council of Educational Research and Training. The Unesco Experts and the members of the Department of Science Education explained the scope of the experiment to the participants through working papers and discussions

It was proposed that with the teaching materials supplied to them they should commence teaching the different disciplines in their schools according to the pattern described in the project. The teachers of each subject would meet separately once every week in the school when a Unesco Expert and a member of the Department of Science Education would tell them how to proceed with their lessons and about what experiments would have to be conducted. The experts would also get the reactions of the teachers to the project, which would be used as feed-back. The experts would also be visiting the schools during working hours periodically to see how the work was being carried out.

PREPARATION OF DRAPT SYLLABUS IN SCIENCE EDUCATION FOR EDUCATION COMMISSION

In consultation with the Department of Curriculum, Methods and Textbook, this Department has produced a draft syllabus in Science for elementary classes I to IV and in individual subjects (physics, chemistry and biology) for classes V to X. This will be considered by the Education Commission.

The Seminar on STS Summer Schools in progress.

The curriculum consists of.

i) Science component of the subject 'Study of Environment' for classes I and II.

ii) General Science Syllabus for classes III and IV

iii) Syllabus for classes V to X in biology and physics, and in chemistry for classes VI to X.

The curriculum was prepared in terms of content demonstration by teachers and students activities.

BIOLOGY TEXTBOOK

Section III of the Biology Textbook, 'Diversity of Animal life' was brought out in August 1965. With this Section 400 pages have already been printed and the matter for Sections IV and V has been sent to the press and the other two Sections, namely, VI and VII, are also ready for printing. It is hoped to bring out the Sections IV and V early in March, 1966.

SCIENCE TALENT SEARCH

To evaluate the output of these Summer Schools a three-day seminar was held from August 9 to 11, 1965, at the Department of Science Education, N.C.E.R.T., under the Chairmanship of Dr. D. S Kothari, Chairman, University Grants Commission. The main recommendations of the experts present at this seminar are as follows

1. At these Summer Schools, opportunities should be provided so that the awardees can develop their creative

abilities to the fullest extent.

2. An individual-oriented flexible programme should be designed which can be tailored according to the needs of the individuals

3 The Centres for Summer Schools should be chosen with great care so as to provide a proper scientific environment to the participants.

4. Right from the first year, an effort should be made to obtain the choice of the student and place him in the appropriate Summer School

5 The programme should not be packed with routine lectures, laboratory work or workshop practice Instead of this packed programme an effort should be made to make the programme as flexible as possible so that an individual can do his work according to his interest and aptitude

6. Individual and group discussions should be encouraged as much as possible

7. The laboratory work should not be of a routine type and should be well-designed so as to suit the needs of the participants.

8 Guest lecturers should be invited so that they may motivate the students by their informative and interesting exposition of modern, yet elementary, subject matter

Books
For your science library

Principles of Biology: WHALEY, W. C. *et al.* Harper & Row, New York and John Wetherhill, Inc, Tokyo (3rd ed) 1965 pp. xviii + 776.

This is the third edition of a book which has been in use for over a decade Five professors of biological science have collaborated to write this textbook, not to speak of other eminent contributors. The result of this collaboration is a sound scientific piece of writing, dealing with biology in an integrated manner and with the major emphasis on development and function. A perusal of the contents shows that the present edition pays more attention to the physical science foundations of biology as well as other fields of modern biology like cell structure and cellular metabolism which are receiving much notice these days. The study of the molecular basis of genetics is introduced in the form of concepts and a new chapter on health and disease is included.

For an understanding of the broad aspects of biology a knowledge of the basic principles of chemistry is necessary, and this is imparted in two chapters, entitled 'Principles of Chemistry I and II.' For all processes of metabolism and chemical co-ordination in plants and animals, a knowledge of chemistry is necessary and useful. Of particular interest is the chapter on 'genetics' which explains in simple words, the structure of nucleic acids, the role of DNA and the pattern of inheritance.

The book is very well illustrated and contains a number of electron photomicrographs intended to bring out the ultra-structures of the cell. Every chapter has a list of suggested readings at the end. The book should be very useful to students, both in schools and in colleges, and particularly so to teachers of modern biology who can get a fund of information within the span of one book.

S DORAISWAMI

All about Heredity: RANDAL, JUDITH W. H. Allen, London, 1965, pp. 150.

Genetics has always remained a very fascinating and exciting subject ever since the turn of the century. If the number of publications on the subject is any index then we can say that in genetics knowledge is doubling itself every three years. Equally numerous have been the books which attempt to convey facts of genetics in simple, lucid language, both for the laymen as well as the students of biology. *All About Heredity,* which is an exciting and stimulating introduction to the science of genetics, is one such

book. It is written in such a way as to tempt even a specialist to go through the pages to see how the author has expressed these complicated phenomena in simple style and language.

The author starts with Mendel's first experiments with garden peas and goes on to the latest discovery about DNA, the chemical which makes each of us what we are Part I deals with facts which are well known as the framework of heredity, while Part II contains topics of recent discovery, which are not so clear to many. It includes topics like DNA, breaking the genetic code, blue prints of heredity, faulty genes, etc The second part is fittingly called 'Revolution in Biology.' Every student of biology, whether in a school or a college, will benefit from reading this book.

S. DORAISWAMI

A Books of Methods: BRAND WEIN, PAUL F., WATSON, FLETCHER G. and BLACKWOOD, PAUL E. Teaching High School Series. Harcourt Brace & World Inc., New York. 1958.

The authors feel strongly on two points: (i) every teacher has to make his own personal teaching invention; (ii) a book of methods should not therefore be prescriptive. Rather, it should be illustrative only. This feeling pervades the entire treatment of the subject in the book under review.

The book is divided into six sections dealing respectively with: (i) the special climate of the science classroom; (ii) patterns in teaching science; (iii) inventions in science courses, i.e., course building (iv) determining the success of science teaching, i.e., reappraisal of the method's success; (v) tools for the science teacher; (vi) blueprints for community action.

Every chapter starts with 'A note at the beginning' that prepares a healthy climate for discussion to be held subsequently and it ends in an 'Excursion' into some aspect of the topic discussed in the chapter. This would help the science teacher to do some independent thinking in the context of his own specific situation. It serves as a guide line for the teacher to invent his own personal teaching method.

The discussion on the tools for the science teacher is a sort of survey work. The treatment of some aids to teaching is at times very short: only one page is given to 'The Science Club' and 'The Science Fair.' Some other useful references are, however, given at such places to fill up the gap. This book will be useful as a reference book in any science library.

B. D. ATREYA

SCHOOL SCIENCE

VOL. IV NO. 4

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National Council of Educational Research and Training

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INSTRUCTIONS TO AUTHORS

School Science is a quarterly journal intended to serve teachers and students in schools with the most recent developments in science and science methodology. It aims to serve as a forum for exchange of experience in science education and science projects.

Articles covering these aims and objectives are invited.

Manuscripts including legends for illustrations, charts, graphs, etc., should be neatly typed, double spaced on uniformly sized paper and sent to the Editor, School Science, Department of Science Education, NIE Buildings, Mehrauli Road, Hauz Khas, New Delhi 16. Each article may not normally exceed 10 typed pages

The article sent for publication should be exclusive for this journal. Digests of previously published articles modified to suit the scope and purpose of School Science will be accepted. In these cases the name of the journal in which the original article appeared must be stated.

Please do not underline the headings.

Selected references to literature arranged alphabetically according to the author's name may be given at the end of the article wherever possible Each reference should contain the name of the author (with initials), the year of publication, the subject title of the publication, the volume and page numbers,

In the text, the reference should be indicated by the author's name followed by the year of publication enclosed in brackets, *e.g.*, (Passow, 1962). When the author's name occurs in the text, the year of publication alone need be given in brackets, *e g.*, Passow (1962).

Illustrations may be limited to the minimum considered necessary, and should be made with pen and indelible Indian ink. Photographs should be on glossy paper, at least of post card size, and should be sent properly packed so as to avoid damage in transit.

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Biology and Human Welfare

P. Maheshwari
University of Delhi, Delhi

MUCH of our material progress is due to science. All our modern facilities of communication (trains, steamships, telephones, telegraph, radio, television, automobiles, jet planes, and space ships) stem from discoveries in the physical sciences. Thus, the 'Puffing Billy' first hauled coal in 1813 and the first railways for passengers were opened in 1830. In 1838 the steamship 'Sirius' crossed the Atlantic in 19 days, and the first telegraphic messages between the UK and the USA were exchanged in 1858. Recently we have been hearing of space flights and interplanetary flights and we are promised a landing on the Moon in 10 or 20 years although a safe return has not been guaranteed so far. Chemists have provided us with many synthetic substances like glass, bakelite, plastics, rubber, dyes and perfumes. In addition, we have many other things like washing machines, pressure cookers, electric lighting and heating, electric fans, air-conditioners, printing presses, typewriters and so on, which even kings and monarchs did not possess in the past. All these developments have taken place within the last 150 years or less.

The above achievements in the physical sciences are indeed important and even spectacular but those in the biological sciences are no less so. Consider for instance, some of the advances in medicine. In the 19th century only one baby in India survived out of four or five. Now it is three or four out of five, and in western countries infant mortality has been reduced to only one per cent. Smallpox, plague, typhoid, malaria and cholera were common in the living memory of the older ones amongst us. Today we have controlled almost all of them except diseases like cold and influenza which are caused by viruses. Our understanding of these infectious diseases began with the work of Pasteur who first showed the role of micro-organisms in fermentation and in the spread of disease. On the one hand, this was followed by things like vaccination, preventive inoculation and injections of anti-toxins. On the other hand, there came some spectacular ad-advances in surgery. Up to the middle of the 19th century about half the amputations resulted in death and the percentage was much higher in cases of abdominal surgery. This was not primarily due to the injury sustained in the surgical operation but to the after-effects caused by infection of the wound by bacteria. When Lister, a British surgeon, learnt of Pasteur's work on micro-organisms, he introduced new methods of antisepsis and asepsis. About the same time anaesthetics were also introduced with the result that opera-

Adapted from an address given as President of the National Academy of Sciences of India at its 34th annual meeting held at Muzaffarpur on February 13, 1965.

tions became virtually painless and the number of deaths in surgical wards quickly declined. With the discovery of sulpha drugs and antibiotics like penicillin the situation has improved still further.

The Population Explosion

The general decline in death rate and the great decrease in infant mortality has, however, raised other problems. The population is steadily increasing and tends to double itself in only about 40 years. While formerly we were threatened by disease, today we are threatened with something worse, *i.e.*, starvation. It is said that in the days of Magasthenes India was a land of milk and honey, but at present the position is quite different. We are now importing foodstuffs from other countries and in spite of frequent promises toward self-sufficiency our position continues to deteriorate year by year. What are the causes of this misfortune? Well, even a hundred years ago the population of India was only 100-150 million. When I was a school boy fifty years ago, it was 300 million and now in my children's days the population of the India-Pakistan subcontinent is nearly 600 million. What it may be toward the end of the century is anybody's guess, but demographers do not hesitate to place it near about 1000 million for India alone. One expert said that if all the human beings of the world died as result of a sudden catastrophe, and a single Indian, Chinese or Indonesian couple survived, the world would be fully rehabilitated in 600 years. This estimate assumes that each couple would have four or five children during their lifetime which nearly approaches the average number in south-east Asia

This tremendous increase in population caused by a steady birth rate and a declining death rate, has given rise to serious problems not only of underfeeding but also of improper feeding Mr. Raymond Ewell of the New York University has recently predicted that unless proper steps are taken famine might reach serious proportions in India, Pakistan and China in the early 1970s. He warns that 'this would be a famine on a scale never before experienced in the world's history' and that 'a stable government is unlikely to be maintained in countries where a high percentage of the population is literally starving.' Hunger fetches the wolf out of the woods, it demoralizes people and promotes thieving and robbery. A Sanskrit poet has said:

बुभुक्षितः किं न करोति पापम्,
क्षीणा नराः निष्करुणा भवन्ति ।

Methods of Increasing Food Supply

Before discussing this point further it is important to realize that there is only one ultimate source of food for men and animals, whether they are vegetarians or non-vegetarians. This comes solely from plants. They alone have a green pigment called chlorophyll with the help of which they can combine, in the presence of light, two simple substances—carbon dioxide and water—and produce sugars, starches and various other things on which our life and happiness depend. Animals do not possess this property and in spite of his ingenuity, man has not succeeded in

unravelling all the mysteries of this master chemical reaction. Give the most brilliant chemist of the world all the furnances, retorts, catalysts and complicated glassware, and he can produce only soda water from carbon dioxide and water. While one line of work no doubt, is to try to understand more about the photosynthetic reaction and to duplicate it in the laboratory, another and more fruitful line at least for the immediate future is to study the plant itself and make it do a better job than it is doing already.

As to the means of increasing our food supplies, we could then try one or several of the following methods: (a) increase the area of land under cultivation; (b) increase the area under food crops while reducing that under some others; (c) improve the yield per acre of existing land; (d) produce food from the sea, or the algae, or some other unusual sources. Now, while there are some portions of the earth's surface which are lying uncultivated, these are in the jungles of the tropics, or in desert lands, or in places which are too cold and inhospitable To use these areas we require not only much technical skill but also a great deal of money. We could irrigate Rajasthan desert, we could freshen sea-water and use it on land, and we could perhaps cause artificial rain. These are no doubt all possibilities but they are not likely to materialize in the immediate future.

The first and most important source of additional food is, therefore, from the existing crops themselves whose yields can be greatly increased through several methods such as (a) planting of superior seed; (b) application of artificial fertilizers, and (c) control of weeds, pests and parasites. In fact the yields of cereals in India are only about one-third of those in the advanced countries It is also possible that the culture of such microscopic organisms at *yeast* and *Chlorella* may provide us with new and cheap sources of proteins. We shall discuss some of these one by one.

Genetic Improvement of Plants

A good many of the economic plants of the world have been subjected to extensive selection and hybridization resulting in an improvement in yield of as much as 40 per cent in many cases This may be illustrated by referring to the sugarcane on which some significant work has been done right in India.

Although many varieties of cane are grown in the tropics, only three types are important in India. The first or noble canes (*Sachharum officinarum*) are grown in tropical and sub-tropical India as well as Indonesia, Hawaii, West Indies and Mauritius. They are very rich in sugar and are also suitable for chewing purposes owing to their low fibre content and thin rinds. They, however, need a comparatively equable climate and very careful cultivation combined with liberal manuring and irrigation Another disadvantage is their susceptibility to a number of diseases and pests. The second type, called medium canes(*S. barberi*), represent a class which grows well under sub-tropical conditions. Besides northern India, they are also cultivated in southern

Africa, Louisiana, Northern Australia and parts of China and Japan. These are thinner than the noble types and have a lower sugar content. In addition their rinds are thicker and they have more fibre so that they are less suitable for chewing purposes. However, they possess other desirable characters like a deeper and more vigorous root system and narrower leaves which render them resistant to drought and frost. They also show greater resistance to certain pests and diseases than the noble canes. Finally there is a wild species, S. *spontaneum*) of which there are many varieties thriving in various parts of the world even under conditions of the greatest neglect. These are able to tolerate all kinds of adverse conditions such as drought, water-logging and soil salinity. In many parts of India this plant is an obnoxious weed which infests large areas of the soil. It has very thin stems with hard rinds and narrow leaves. The structure of the leaves, stems and roots shows various adaptations which make the plant resistant to most of the pests and diseases affecting the cultivated canes.

C. A. Barber and T. S. Venkataraman were among the first to engage themselves in producing new and improved types of cane combining the 'blood' of all the three types. When the wild cane is crossed with the noble cane, this step is called nobilization. Frequently two or three such nobilizations are necessary before the desired result is obtained. By an appropriate programme of triple hybridization between the wild, medium and noble canes, carried out at Coimbatore and later in the other cane growing areas of the world, it has been possible to evolve types with satisfactory juice value as well as the capacity to grow under adverse conditions. The Coimbatore hybrids are now being grown all over India and have resulted in a 50 per cent increase in yield over the figures obtained for the older varieties.

Valuable work of a similar nature has also been done on wheat by B. P. Pal and on other crops by various plant breeders and geneticists in the country, but this needs to be strengthened and carried out on a much larger scale. A good example of the results of such work is the hybrid maize industry of the USA which has in itself raised the yields of maize by 30 per cent.

Soil Nutrients

Of the ten major elements required by plants nitrogen, potassium and phosphorus are the most important and out of these the one which is most often in short supply is nitrogen. Sir William Crookes was so impressed by the need of fixed nitrogen for stepping up the yields of wheat that he wrote as follows in 1899:

'It is of urgent importance today, and it is a life and death question for generations to come. I mean the question of food supply. Many of my statements you may think are of the alarmist order; certainly they are depressing, but they are founded on stubborn facts. They show that England and all civilized nations stand in deadly peril of not having enough to eat. As mouths multiply, food resources dwindle. Land is a limited quantity, and

the land that will grow wheat is absolutely dependent on difficult and capricious natural phenomena. I am constrained to show that our wheat-producing soil is totally unequal to the strain put upon it. After wearying you with a survey of the universal dearth to be expected, I hope to point a way out of the colossal dilemma. It is the chemist who must come to the rescue of the threatened communities. It is through the laboratory that starvation may ultimately be turned into plenty.'

He further said: 'The fixation of atmospheric nitrogen therefore is one of the great discoveries awaiting the ingenuity of chemists. It is certainly deeply important in its practical bearings on the future welfare and happiness of the civilized races of mankind. This unfulfilled problem, which so far has eluded the strenuous attempts of those who have tried to wrest the secret from nature, differs materially from other chemical discoveries which are in the air, so to speak, but are not yet matured. The fixation of nitrogen is vital to the progress of civilized humanity. Other discoveries minister to our increased intellectual comfort, luxury, or convenience, they serve to make life easier, to hasten the acquisition of wealth, or to save time, health, or worry. The fixation of nitrogen is a question of the not far-distant future. Unless we can class it among certainties to come, the great Caucasian race will cease to be the foremost in the world and will be squeezed out of existence by races to whom wheaten bread is not the suff of life'

Fortunately the challenge was met In 1913 the German chemist Fritz Haber found the way to fix atmospheric nitrogen and humanity was saved!

During recent years many factories have been started in India for the manufacture of fertilizers. The production of ammonium sulphate began in Mysore in 1938 and in Kerala in 1947. The factory at Sindri was started in 1951, another at Nangal in 1961, a third at Rourkela in 1962 and a fourth at Trombay in 1965. However, their total annual production of ammonium sulphate and superphosphate is much less than the actual requirement so that our crop yields are no more than one-third or one-fourth of those in other countries.

Investigations made during the last 30 years have shown that apart from the ten major elements known to be essential for plant growth (carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, calcium, iron and magnesium) there are several others which are also important although needed only in minute quantities. Of these copper, boron, silicon, chlorine, manganese, zinc and molybdenum are specially noteworthy. A dieback disease of citrus, occurring in Florida, California, South Africa and other places, has been traced to copper deficiency, lack of boron caused serious damage to apple crops and sugar beet; absence of manganese often gives rise to chlorosis; and zinc deficiency is known to cause a 'rosette' of apples, mottle-leaf of citrus and 'yellows' of walnuts.

Quite a few of the deficiency diseases can be cured just by spraying a suitably

prepared solution of the element in short supply, or adding it to the soil, or by inserting a pill into a bore-hole in the trunk of a tree. However, simple soil applications do not always give the desired result. For example, the chemical analysis of a soil may show adequate amounts of iron and yet the plants grown on such soil show unmistakable signs of iron deficiency. This may be due to the unavailability of the iron because of a high pH or some other factor. To give an example, if too much lime is put on a soil the pH may go up to 7, 8, or more with the result that phosphates and some micronutrients become unavailable. The poor development of chlorophyll thus caused is designated as lime-induced chlorosis Under such circumstances providing more iron to the soil is of no use because this will be thrown out of solution just as promptly as that already there. Spraying is better, or one may try to make the soil slightly acidic. It has also been found possible to keep the iron soluble by using ethylene diamine tetracetate. This forms a soluble complex with the iron which now becomes available.

The trace elements are in the nature of catalysts or parts of enzyme molecules which are essential for the normal metabolism of plants. Serious disturbances may result in their absence. The internal cork of apples and heart-rot of sugar beet have been found to be due to boron deficiency and can be prevented by the application of sodium borate (borax) to the crop. The mottle-leaf of citrus can be cured by applications of zinc. Large tracts in New Zealand where both sheep and cattle suffered from a 'pining sickness', have been rendesert area has been converted into and in Southern Australia a large desert area has been converted into good agricultural land by applications of minute amounts of sulphates of zinc and copper. In South-east Australia a small addition of copper not only enabled the growth of oats, wheat and lucerne but also improved the wool of the sheep grazing on the fodder. In Southern Australia homeopathic doses of molybdenum enabled miles of worthless land to 'blossom as a rose'.

It is to be noted that while the trace elements are absolutely essential, even a small excess may do harm to plants and poison them. This is of course also true of the major elements although in a different way. For example, if a farmer applies too much nitrogen fertilizer to strawberries he causes the carbohydrates present in the plants to combine with the nitrogen and the fruits may become tasteless owing to lack of sugar. On the other hand, with leafy vegetables like spinach and *Chenopodium*, considerable quantities of nitrogenous fertilizers can be used with advantage for under their effect the plants produce lush dark green leaves and tender stems, which are much richer in proteins and therefore possess a higher food value. With wheat an excess of nitrogenous fertilizer produces weak stems that are likely to cause the plants to fall over or 'lodge'. The dosage as well as the time of application of the fertilizer have, therefore, to be studied in each case.

It is interesting to note that the presence of certain other elements in the soil may be deleterious rather than

beneficial to plants or to animals, as the case may be. Among these are arsenic, selenium and thallium. The so-called 'alkali disease' is a good example of this kind. About the middle of the 19th century it was observed that animals in some areas of western USA became debilitated and often died in large numbers. It was later found that (a) certain plants absorb selenium from the soil and the forage produced in such areas contains small quantities of this element, (b) even one part per million of selenium may kill animals; and (c) such soils become dangerous in those years when there is not enough rainfall or irrigation water to wash out the selenium. On the other hand iodine, although not needed by plants, is quite essential for the health of animals and human beings When the water and the plants of any area lack iodine, this has to be supplied from outside

Mention may also be made here of the recent development of soil conditioners which, if they can be produced cheaply, may step up yields appreciably One of the problems of agriculture is to maintain a good soil texture to permit the absorption of water and air and to prevent hardening of the soil. A good soil texture can be achieved by the addition of organic manures. Where these are insufficient, a pound of krillium may be used in place of a hundred or one thousand pounds of compost. Krillium has no plant nutrients but is remarkably effective in improving the physical texture of heavy soils.

Plant Protection

While superior breeds of plants under proper conditions of irrigation and soil fertility will naturally give higher yields, plants like animals suffer from many kinds of diseases and it is important to maintain them in good health in order to obtain the best yields. That fungi, bacteria, viruses and insects take a heavy toll is now well known, but a few examples may not be out of place.

The potato blight (*Phytophthora infestans*) caused havoc in Europe in the middle of the nineteenth century. In 1845 a terrible wave of the blight swept the potato fields from Norway to Bordeaux reaching the extent of a national calamity. In Ireland the disease was noticed in the last week of August and rapidly developed in an intensity unequalled in any other country In 1846 it was worse, in 1847 milder, but bad again in 1848 The great famine which followed the disease had repurcussions which lasted for many years The population of Ireland, which was eight millions in 1841, had lost a million by death and immigration by the next census in 1851. The impoverished country was unable to support even these reduced numbers and there was a steady stream of emigration which lasted throughout the century.

Another fungous disease (*Hemileia vastatrix*) wiped out the coffee plantations of Ceylon towards the latter part of the 19th century. Due to the attack of this rust the coffee bushes were so seriously affected that they became unprofitable and coffee is no longer grown on a commercial scale in Ceylon Recently, the blister blight of tea, caused by *Exobasidium vexans*, has appeared in South-east Asia and threatens to be

another serious menace. The 'Panama disease' caused by *Fusarium cubense*, a soil organism, has endangered the banana industry in Jamaica and Central America resulting in the abandonment of banana cultivation on thousands of acres. In India the three wheat rusts have been causing an annual loss of 60 million rupees.

Returning to the potato blight, its repeated ravages led to a testing of all known varieties of potato for resistance against it and expeditions were organized by several countries to obtain a number of wild varieties from the original home of the potato in South America. As the result of inter-crosses between these varieties it has been possible to create new types which show considerable resistance to the blight as well as to a number of virous diseases. What has been done with the potato is also being attempted with many other crops and today plant breeders and plant pathologists are working in close cooperation to develop new varieties of plants which are not only superior in yield but are also resistant to most of the diseases which generally affect them.

The use of copper sulphate, copper carbonate and organic mercurial dusts has made it possible to control many seed-borne diseases, and there has been a similar improvement in the development of fungicide sprays. While Bordeaux mixture is still very popular, the substitution of commercial limesulphur, wettable sulphur and other substances have greatly increased the effectiveness of control.

The value of DDT in controlling insect pests is now well known to every one. A more recent development is the possibility of applying a chemical to the roots or some other aerial part of a plant or injecting it into its tissues so that they become distasteful to the insects without affecting the usability of the produce. It is, in some respects, parallel to the vast developments which have taken place in human and animal pathology, for example, the use of quinine, atebrin and paludrin in malarial prophylaxis and treatment. The most useful chemical explored in this connection, is octamethyl pyrophosphoramide, called Schradan or Pestox 3. If applied to the soil or introduced into irrigation water, it makes plants toxic to sucking insects for 3–6 weeks. Another similar chemical is bis-isopropylaminofluorophosphine oxide or Isopestox. This is toxic for only 7-8 days so that crops can be treated with it almost up to the time of harvesting.

Systemic chemicals have also been tried during recent years for the control of fungal diseases. Earlier work was directed mostly against diseases of woody trees as in the case of the Dutch elm disease, but some nitropyrozoles when injected into tomatoes have been found to delay the appearance of lesions of *Alternaria solani*. This is a wide open field for future research .

Control of Weeds

A farmer's life is a constant battle with weeds, and until recently mechanical cultivation, which is both arduous and costly was the chief method for getting rid of them The discovery that certain synthetic hormones will destroy some kinds of plants and leave others relatively unharmed has proved to be

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spray. The advantages are (a) saving of time and money, (b) less mechanical damage, (c) and control of a wider range of weeds The disadvantages are that (a) it is difficult to arrive at the correct timing of a combined spray, and (b) the action of one constituent may impair or nullify the effect of the other by forming insoluble salts or by preventing the absorption of some elements.

Shortcomings of Existing Crop Plants

Besides improving our existing crop plants and taking proper care of them, there is also another approach to the problem which may be illustrated by giving an example. If an engineer had charge of engines which did not produce a sufficient amount of energy and he were asked to produce more power, what could he do about the matter? In the first place he can perhaps construct a large number of engines of the same type. If he has more brains, he can try to improve the performance of the existing engines by lubrication and minor adjustments. If he is really clever, he could try to make an entirely new design. What we have considered so far are methods of the second order

Before we enter into a further consideration of this point, it is well to understand what are the defects, if any, in the existing photosynthetic engines. In the first place most of our crop plants convert only a very small percentage of the solar energy falling on them into organic material. Much of the light falling on a leaf is reflected back, or passes through the leaf, or is

absorbed by the tissues to serve as heat energy. Normally less than 1.0 per cent is utilized in photosynthesis. The very nature of plants makes them ineffective for a full utilization of sun's energy. They have a slow rate of growth and it is only for a short period that they are at the peak of their activity. In wheat, for instance, during the first six weeks only about one fourth of the maximal leaf surface is developed. During the next two weeks an additional one fourth is formed It is only in the ninth or tenth week that the full leaf surface is developed. After this the plant is active for another three or four weeks and is then ready for harvesting. Thus the process starts at zero and is slowly built up until maximum efficiency is reached. This lasts for a short time only after which the event comes to a complete stop and must be started anew by sowing a fresh crop. Further, while we ask the wheat plant to synthesize sugar and starch for several weeks, eventually we eat only the small fraction stored in the grain. In mango it is only the flesh of the fruit that is edible, and the stem, leaf and root are of no value for this purpose. In other words, only a part of the organic material synthesized by the plant can be eaten and the rest is wasted from the point of view of nutrition.

In this respect certain microscopic algae present some advantages over our ordinary crop plants. Several of them can be cultured on a large scale, but so far no systematic study has been made to find the most suitable types for food production. One of these, *Chlorella pyrenoidosa*, has received considerable attention in the USA, in Japan they have experimented with *C. ellipsoidea*, and in England with *C. vulgaris*.

Chlorella is unicellular. Being only 3-10 μ in diameter it appears as an insignificant little blob under the microscope. However, the cells multiply very quickly (once every 12 hours) and require only simple inorganic salts for their growth. Normally the alga manufactures carbohydrates but if supplied with nitrogenous salts and other minerals and given plenty of light, it shows an amazingly high protein content which may go up to as much as 58 per cent on a dry weight basis. If the nitrogen is reduced and the plants are given plenty of carbon dioxide, good light and a long period of growth, the proportion of fat goes up to 86 per cent of the dry weight.

This is significant because the present food shortage of the world is not so much in terms of carbohydrates but in fats and proteins. Another significant point is that the fats as well as the proteins of *Chlorella* are of high quality from the point of view of human beings. The fat is probably as good as that from *soya* bean and the protein contains all the ten essential amino acids. All the important vitamins are also present. Unfortunately the cost of growing *Chlorella* is prohibitive at present. Although the major nutrients such as carbon dioxide, water, and nitrogen salts are not expensive and there is plenty of sunlight in the tropics, it still needs quite a set-up and high technical skill to grow the plants on a large scale. It is of course possible that there are other algae which

are superior to *Chlorella* and these can be further improved by selection, hybridization and mutation. It may be recalled that the present strains of *Penicillium notatum* are many times more productive than the original strain of Flemming. And what has been done with *Penicillium* can also be tried with *Chlorella* and other organisms. What is expensive today may become cheap tomorrow! This kind of research must, therefore, continue to be pursued.

For the manufacture of proteins and fats, we must also consider another well known microscopic organism, the yeast Yeast cells have no chlorophyll and are therefore unable to live on a purely inorganic medium However, their requirements are very modest and they thrive without difficulty on ammonium salts and molasses. Further, it is possible to substitute molasses by hydrolysed sawdust and pulping waste. Just as *Torulopsis* is suitable for producing proteins, so two other types—*Endomyces* and *Rhodotorula*—have proved to be very satisfactory for the production of fats.

In conclusion, we may say that man does not live by bread alone and yet it is hard to stay alive without it. In the means of transport and communication and in methods of waging war modern man has made truly phenomenal advances over his ancestors Can we say the same thing, however, about agriculture and the one essential thing called food? In this respect we are still bound to past, for most of our crop plants had already been brought into cultivation four thousand years earlier.

What is the reason for this slow progress in a sphere which is of such importance to our lives and which threatens our very existence? The only answer is that biological phenomena are far more complex than physical and chemical phenomena and it takes more time, energy and resourcefulness to understand them. Also, the budgets for biological laboratories are the lowest, their equipment is old and antiquated, and in the name of economy the axe is always ready to fall upon them.

The Scarcity of Biologists

Even more distressing than lack of funds is the comparatively small number of biologists in the country. Any one who has served as a member of the science admission committee of a university must have noticed that students keep physics and engineering as their first choice, then come chemistry and medicine, while biology and agriculture come last.

India is predominantly an agricultural country and yet we suffer from constant scarcity of food. This is not because the Indian farmer is less industrious than his western counterpart or because the land is poor but simply because we have not used scientific methods in our agriculture and are still bound to the hoary past in our techniques of crop production. Dr. D. S. Kothari, Chairman of the University Grants Commission rightly remarked: 'Modern agriculture is really applied biology It is necessary in relation to our plans of agricultural development and increased food production that the effort on agricultural education should be very much more than what

it is today'. Another distinguished physicist J. D. Bernal writes as follows in his book entitled *Science in History* 'In the near future, given an end to the cold war, the rewards of biology are bound to lead to its very rapid increase. ..... biology offers problems of great complexity where ingenuity is at a premium. Even the simplest of them (living organisms) surpasses a thousand or a million-fold in absolute complexity the most complicated systems devised by men. Biology cannot in the nature of things be as simple as physics or even chemistry, since it includes these subjects in itself. Nor can it be expressed in the language of precise mathematics, because it has too great a multiplicity to describe by enumeration. The problems of an increasing population and of static or decreasing food supplies can be solved only by an active and advancing biology. The very successes of physics and chemistry have ensured that biology should now present the key problems of the whole of natural science, offering a challenge to the understanding of the world in which we live, which will call for far more extensive and at the same time better coordinated efforts than all those which science has dealt with in the past'.

We must carefully consider the causes of this scarcity of men in biology in spite of the overpowering role that this subject has played and will play to a still greater extent in future? In final analysis they can perhaps be traced to three sources. The first of these is the lack of consideration and respect shown by the government to the tillers of the soil. Even the public is much more impressed by a textile or steel factory than by the farm. While paying lip service to the food problem, there has been no real attempt to get at the root of it. The second is the absence of any instruction in biology in many of our schools. At present the majority of the schools in India give no integrated picture of science but teach only physics and chemistry. The result is that the young boy or girl, who has never been exposed to biology in his or her school years, naturally prefers to ask for admission to a course in physics or chemistry and considers biology as an unfamiliar and perhaps more difficult science where it is almost impossible to secure the high marks obtained in physics and mathematics and where the chances of good employment are less certain. The third reason is the rather uninspiring teaching of biology in our educational institutions. What is taught at present is a travesty of the subject. This last point needs to be considered in a little more detail.

One factor, which makes the present courses in biology rather dull, is that their contents are mostly or entirely descriptive. While the morphological part must still form the basis of biology and has to be done well, this cannot be the only thing, and physiology, ecology, genetics, and the role of biology in human life are subjects which also demand adequate attention. A large fund of biological information acquired during the present century finds no mention in most of our texts nor do they provide any information about the interdependence of plants and animals. Problems like what happens in photosynthesis or respiration and how living organisms respond to external and

internal stimuli elicit greater interest in the minds of students and are more important than learning the characters of a family of plants or describing the pectoral girdle of frog. It would be appalling if a school student should get the impression that biology is nothing more than sketching the shapes of leaves and bones or just a system of naming plants and animals in unfamiliar language.

Conclusion

Although out of all sciences biology has the greatest applications in everyday life, not all the work in this field need be inspired by selfish motive alone That is not the way science has progressed in the past or will progress in the future Basically science is a quest for truth and many persons are motivated to take up biological research just to satisfy their curiosity It is out of such work that the whole field of antibiotics emerged Similarly the chapter on plant hormones emerged from Darwin's (1880) question as to why plants bend towards light. There are still many such questions demanding explanation For example, in spite of many years' work we do not quite know how water rises to the tops of such tall trees as the *Sequoia* and *Eucalyptus* Why do the leaves of *Mimosa pudica* collapse when touched? Why do leaves turn yellow and red in the month of October in western countries and in February in our climate? Why is it that in the mango and in *Amherstia* it is the new leaves that show the red colour? How does a bat see its way in darkness? Why do fishes and birds travel for hundreds of miles and then return to the same spot which they had left earlier? Can life be created in the test tube? Can fertilization and embryo development be completed in the higher plants and higher animals *in vitro*? Can the nitrogen-fixing bacteria which live in symbiotic association with the roots of leguminous plants be made to attach themselves to our cereals and to other plants so that we do not have to worry too much about adding nitrogenous fertilizers to the soil? What is the key to heredity and can we direct the changes in the molecules of heredity in accordance with our wishes?

It may also be pointed out that biology is concerned not only with plants and animals but with man himself. If we ask ourselves What is it that endures best? A great city? Or a large industrial state? Or the best built steamships? Or buildings of cement and iron? Or great bridges, minarets and forts? The answer is a definite no, it is men and women of ideas who are the most important. Even if a city has only a few mud huts but a few great men and women, it is in fact the greatest city in the whole world. In living memory we saw that although Gandhiji lived in Sabarmati Ashram in Ahmedabad and Harijan Colony in Delhi, his presence continued to attract visitors from all parts of the world.

How are we to get these great men and women? That is the toughest problem before humanity. It is rendered extremely complex because while it is not too difficult to measure the disease-resisting properties of sugarcane, or the milking qualities of a cow, or the fleetness of a race-horse, it is not the same

with the measurement of spiritual and intellectual values. If we want a disease-resisting wheat or an intelligent sheep-dog, we breed them, and we know that we cannot get them in any other way. We cannot hope to obtain them by manuring, watering and generously tending a wild grass, or by careful feeding and training of a mongrel dog. The study of human heredity teaches us the same lesson. There are families in man in which some special ability is inherited from generation to generation. There are others which show the inheritance of some defect like haemophilia, colour blindness, tendency towards diabetes, and so on. Even the pattern of baldness is hereditary. Obviously then, if we are to improve the human race we must make a conscious effort in that direction. Unfortunately marriages among humans are arranged on an emotional rather than a biological and genetical plane. There are, however, a few things that can perhaps be undertaken right away. People from a stock suffering from a marked hereditary defect such as insanity, epilepsy or mental weakness have no right to reproduce and hand on this defect to the next generation.

We must also examine our social laws to make sure that they do not favour the less gifted, less able, and less energetic members of the community while discouraging reproducation of those who are better endowed. While we must do our best for all our fellowmen, we dare not sacrifice the future for the present. It is dangerous for a nation to breed chiefly from its inferior stocks. And yet that is what seems to be happening at the moment. While the more intelligent and educated are aware of the dangers of over-population and consequently tend to marry late and have fewer children, the others consider children to be just an act of God and are undisturbed by this steady deterioration of the germplasm. If this goes unchecked, during the next fifty years we shall have a much larger number of the feeble-minded and much fewer pupils of scholarship ability. This genetical erosion threatens all countries but particularly those which are over-populated.

How are we going to stop it? Before we act we need a greater knowledge of human biology. Which traits are inherited and which are not? Which are the most desirable qualities, which are not so desirable but can be tolerated, and which are the ones that we root out at all costs? The second point is to see that no bright child is deprived of education and progress just because of lack of money. Poverty has sometimes been a bar to higher education and it is our duty to see that this does not remain so in future. We must pick out the most talented boys and girls as early as we can spot them and give them our best attention in all possible ways.

All this requires a lot of work. Before we think of space ships and rockets and travelling to the Moon let us consider what we can do right here with the plants, animals and human beings on this planet. We need not try to climb on the bandwagon of other nations simply because certain types of research appear to be more fashionable than others. We have our own problems to

solve — problems of food, health and population — and must see that there is a proper distribution of the scientific effort in India. If we are to avoid a serious crisis 20 or 25 years later—, the present imbalances must be corrected and we must redress this persistent neglect of the life sciences so that our children and grand children do not blame us for their sufferings. We cannot wait for this. We must do it now and immediately.

Gravitation - Relativity - Geometry

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IT is said that when Archimedes sat in his bath tub, modern science was born and when Newton sat in his orchard it came of age. Newton re-organized the then existing knowledge about motion of bodies into his three famous laws of motion and made the most capital discovery of the law of universal gravitation. His law of gravitation may be stated in the following form:

> Every particle in the universe attracts every other particle with a force which varies directly as the product of the masses and inversely as the square of the distance between them.

It is well known that with the law of gravitation and with his three laws of motion, Newton could explain diverse phenomena like the motion of a pendulum or of a spinning top, the motion of the planets, the phenomena of tides and so on. As a matter of fact the entire edifice of modern engineering stands essentially on the three laws of Newton. Let us examine his law of gravity in detail.

Universality of the Law

Newton's law is called the Law of Universal Gravitation. In the statement of the law which we have given above there is a mention about something that happens with any two particles in the universe. One may as well wonder: What led Newton to describe something which should obtain anywhere in the universe when his observations were limited to his orchard only? This is a question which can be asked about all laws of physics. Boyle performed a set of experiments in his kitchen and deduced what is known as Boyle's law that at constant temperature, the pressure of a gas varies inversely as its volume. Nobody has ever suggested that this law will be true only if the experiments were performed in Boyle's kitchen. This points to an essential difference between local or municipal laws and the laws of nature. Laws of nature, as the name suggests, are not laws of a particular place or time but must hold good everywhere in nature.

How does a scientist deduce a law of nature holding good anywhere in the universe from a set of observations limited to his laboratory? Scientists must have before them some criteria by which they must be able to weed out local effects in their observations, single out universal effects and weld these universal effects into a law of nature. Such a criterion must have existed in some form or another since the days of Archimedes when modern science was born.

Such a criterion is known by the name of the Principle of Relativity. A principle of relativity has been known since the days of Archimedes, but the first conscious use of this principle for testing laws of nature was made

explicitly by Einstein only in 1905 and it is no wonder that after that date there has been a phenomenal rise in the growth of our knowledge about nature

Relativity Criterion

We shall now try to understand this criterion of relativity and then see how Einstein used it to test the universality of Newton's law of gravitation.

The physics that is studied in India is the same as the physics that is studied in USA or USSR The experiments that are described in a textbook of physics could be performed anywhere on the earth and if the experiments are performed under prescribed conditions, the same results will follow everywhere But what about the Moon? If the Boyle's law apparatus is transferred to the Moon or to the planet Mars and a constant temperature for the gas is maintained, do we expect the pressure and the volume to vary along the familiar hyperbola? We should really expect the same behaviour but we are not that sure for the Moon or Mars as we were for any laboratory on earth. Let us be more explicit. We have here two comparisons : (i) comparison between results of identical experiments performed at a laboratory, say 'I', in India and a laboratory, say 'U' in USA (ii) a comparison between experiments performed in a laboratory 'I' on the earth and a laboratory 'M' on the Moon. One feels quite sure about obtaining identical results from identical experiments performed in 'I' and 'U' but one is not that sure about the same experiments when performed in 'I' and 'M'. What is the difference in the pair 'I' and 'U' and the pair 'I' and 'M'? Of course 'I' and 'U' are both fixed on the earth while I is on the earth and M is on the moon and the moon moves round the earth. One essential difference which leads to the doubt expressed above is the difference of relative motion 'I' and 'U' have no relative motion but 'I' and 'M' have relative motion. If we can ensure that relative motion between observers will not affect their observations, we can be sure of the identity of results at 'I' and 'M'. The essential feature of the criterion of relativity is to ensure that the relative motion between two observers should not affect their observations of nature. We can state this criterion of relativity in a more refined way as follows.

> If two observers having motion relative to each other describe a certain phenomenon in identical terms then that phenomenon is a phenomenon of nature and the identical description is a Law of Nature.

Einstein's Thought Experiments

We shall now see how the above criterion of relativity was used by Einstein to test whether Newton's law of gravitation was really a law of nature or not.

Many must have observed falling apples before the days of Newton. But when Newton observed the falling apple in his orchard he was conscious that he was observing a phenomenon of nature, yes, a phenomenon of nature in the sense of the definition given here in the earlier section. This was the reason why

from this simple observation he was led to a law of nature. Einstein thought out an experiment to test whether this phenomenon of falling apple satisfied the criterion of relativity in order to be classified as a phenomenon of nature.

Let us think of a lift descending from the top floor of a high skyscraper like the Empire State Building and consider the unfortunate event in which the cable supporting the lift snaps. The lift will then start falling freely under gravity like the celebrated apple of Newton's orchard. Let us further imagine a mathematician A in this freely falling lift. He can, of course calculate the time t (which will be of the order of 2 or 3 seconds for most skyscrapers) which the lift will take to reach the ground. While we, on the ground are worried about what would happen after that time t, the mathematician A, being a wise man, would like to make the best use of these 2 or 3 seconds available to him and so decide to test Newton's law of gravitation. In order to make a comparison we must have another observer B on the ground. Since ordinary persons on the ground would at that moment be thinking about police, ambulance, hospital and such other things, we must imagine B to be a mathematician on the ground who is not normally worried about such mundane things. (It is no wonder that the experiment is a thought experiment *i.e.*, an experiment which is imagined but not actually performed. Who would like to take the place of the wise man A?)

So A decides to test gravity. He takes out a chalkpiece from his pocket, raises it to the level of his eyes and then lets it go. What will he observe? Will he see the piece of chalk moving down towards the floor of the lift? How could that happen? He himself is falling freely *i.e.*, his eyes have the same speed and acceleration as this piece of chalk. As the piece of chalk falls down, he with his eyes also falls down the same distance. Thus the vertical distance between his eyes and the chalk piece does not change. He will find the piece of chalk poised in air before his eyes. For him, the piece of chalk is not falling downwards but remains at rest at the level of his eyes. He may as well be wondering: 'Has the earth gone on vacation? Why is it not attracting this piece of chalk?' Earth is a body in the universe. The piece of chalk is also a body in the universe. For the observer A these two bodies in the universe do not attract each other.

But the other mathematician B on the ground maintains that they do attract each other. For B, the piece of chalk is falling downwards towards the earth. For him the lift and therefore the observer A is also falling freely downwards towards the earth. This means that the two observers A and B have relative motion. We can therefore imagine two observers in relative motion such that the two describe the phenomena of falling objects in different terms. A says objects are not falling, B says they are falling. Thus the phenomena of falling apples is not a natural phenomenon in terms of our definition. The statement of the law of gravitation as given by Newton does not pass the test of relativity criterion

as illustrated by this thought experiment of Einstein.

So what! Does this mean that gravitation does not exist? Well, one has just to throw a stone vertically upwards and not to move away from the place of projection to receive a direct proof on the head that gravitation does exist! (This should again be taken as a thought proof—proof to be thought of but not to be demonstrated!)

This only means that the law of gravitation has to be reformulated in such a way that both A and B describe gravitational phenomena in identical terms.

Problem of Geometry

Let us turn again to the Einstein's thought experiment of the falling lift in order to see that the problem of reformulation of the law of gravitation as referred to at the end of the last section is essentially a problem of geometry

We fix our attention on the observer A. He observes the piece of chalk poised in the air in front of his eyes. Let us imagine that A now gives a tick to the chalk in the horizontal direction away from his eyes. He will then see that the chalk piece sails uniformly in a straight line away from him and strikes the opposite wall of the lift at a point on the same level as his eyes.

Let us next go to the observer B and find out what he has recorded. B has found that the chalk piece has moved onwards as well as downwards. He has thus observed the path, to be a curved line, in fact, a parabola.

It is now our turn to wonder. Is the chalk really moving in a straight line or in a parabola?

The observer B who experiences gravitation in the Newtonion way finds paths of certain objects to be parabolas. The observer A who does not experience gravitation in the Newtonion way finds the paths of the same objects to be straight lines. The difference in the observaions of gravitational phenomena, by the two observers is also reflected in a difference in the geometrical interpretation of curves by the two observers. It appears therefore, that the observation of a gravitational situation is, in some intricate way, related to the geometry used to describe the situation. We are searching for a description of the law of gravitation which would be identical for both obvers A and B. Can we not do it by trying to fix up the identity of the geometry used by both A and B for describing gravitational phenomena? We can; and that is what Einstein has actually done.

In what follows we shall therefore go into the details of development of different geometries to see how such a programme of formulation of the relativistically invariant gravitational theory was successfully completed by Einstein.

Euclidean Geometry

The geometry that is studied in schools is the Euclidean geometry. Some two thousand years back the Greek geometer Euclid collected all the knowledge of geometry existing at his time, organized it and wrote down the oldest known scientific textbooks Euclid's Elements. These books have continued to be in use in more or less unchanged

form all these years. But the geometry described in these Elements would not be called Euclidean geometry simply because Euclid collected the existing knowledge and presented it in an organized form. Euclid did something more than that. He looked into the large mass of theorems of geometry and found that all these theorems could be derived from a set of axioms. These axioms, in their turn, could not be 'derived' or 'proved' but had to be assumed at the start. Euclid enumerated five unproved axioms at the beginning of his Elements and then gave logical deductions of various theorems from these axioms. He very well knew that the entire edifice of geometry that he presented in his Elements ultimately depended on the choice of the five axioms. This is the reason why the logical system of geometry based on the axioms chosen by Euclid is given the name of Euclidean Geometry.

The geometry that we study in schools is the Euclidean geometry. A question naturally arises. Are there geometries which are not Euclidean? What would happen if we discard the five postulates of Euclid and choose some other axioms in their place? Well, one thing is certain—choosing another set of axioms will not be enough. One must be able to use these axioms consistently and deduce from them theorems which are not mutually contradictory. We shall now try to understand two such successful attempts at discovering non-Euclidean geometries.

The Parallel Postulate

One of the five axioms of Newton is the following one which has come to be known as the parallel postulate:

'Given a straight line and a point outside it one and only one straight line can be drawn parallel to the given line and passing through the given point.'

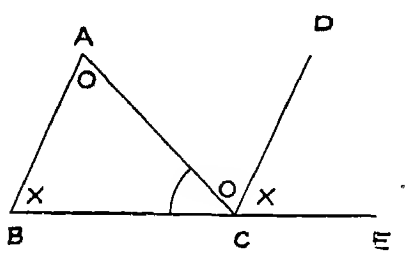
Euclid himself was not happy with his postulate. He thought that with the help of the other four axioms and with the help of theorems derived from these four axioms it would be possible to prove this parallel postulate as a theorem. He made many attempts in this direction but failed. And then only, almost reluctantly, he admitted this postulate in the list of his unproved axioms. For almost two thousand years after Euclid this particular postulate has been the subject of study by many geometers. Many tried to replace this postulate by another one and develop a self-consistent geometry. The first such successful attempt was that of the mathematician Lobatchewsky in 1820's. He kept the first four axioms of Euclid unchanged but replaced the fifth one by the following:

> 'Given a straight line and a point outside it at least two straight lines can be drawn parallel to the given line and passing through the given point.'

Lobatchewsky was able to develop a consistent geometry based on these postulates. One of the first propositions of his geometry was: 'Given a straight line I and a point O outside it, if two parallel straight lines can be drawn through O parallel to I, then three such lines can be drawn through O. If three parallel lines can

be drawn through O parallel to I, then four such lines can be drawn and so on. Thus from an outside point O an infinite number of straight lines can be drawn parallel to a given line I.'

It is not very difficult to realise that Lobatchewskian geometry will be quite different from Euclidean geometry. As an illustration of this difference let us take the well known theorem about the sum of the three angles of a triangle. In Euclidean geometry this sum is two right angles. If we try to recapitulate the proof of this theorem of Euclidean geometry we shall see that the proof depends on producing BC to E and drawing CD parallel to AB. (see figure below). Now AB is a



straight line and C is an outside point. In Euclidean geometry from C only one straight line CD can be drawn parallel to AB and so the familiar proof of this theorem could be given. But what would happen to this proof if from C two straight lines could be drawn parallel to AB?

In Lobatchewskian geometry the corresponding proposition for the sum of the three angles of triangle is: The sum of the three angles of a triangle is always less than two right angles.

At this stage one may venture a question. Which of the two geometries is the correct geometry? But, wait a minute. What does one mean by 'correct' geometry? Let us remember that what we are discussing at present is mathematics and not physics. There are no laboratory tests for propositions of mathematics. Propositions of mathematics are self-consistent creations of human mind based on a set of assumed results, a set of accepted procedures and that queer abstraction of common sense known as logic. A triangle of geometry cannot be constructed in a workshop. It can only be constructed by geometrical (not physical) constructions. In that sense any self-consistent system of geometry is as correct as any other.

A more sensible query about these geometries would be the following: Which of the two geometries is more useful? The ultimate aim of this article is to answer this query. So let us wait till we reach the end of our discussions

Reimannian Geometry

We turn again to the parallel postulate. I is a given line and O is a given point outside it. Euclid assumed that only one straight line can be drawn through O parallel to I. Lobatchewsky assumed that more than one straight lines can be drawn through O parallel to I. One case was still left for consideration. As late as the middle of nineteenth century, Riemann accepted the first four axioms of Euclid but replaced his fifth postulate by the following

> 'Given a straight line and a point outside it, no straight line can be drawn parallel to the given line through the given point'

He was able to construct a self consistent logical system of geometry based on these postulates. Thus was constructed the third geometrical system known as Riemannian geometry. In Riemannian geometry there are no parallel straight lines; in other words, all straight lines must be intersecting straight lines.

To realise how completely different this geometry is from the familiar Euclidean geometry or the unfamiliar Lobatchewskian geometry, let us consider the triangle-theorem in this geometry. In Riemannian geometry the sum of the three angles of a triangle is always greater than two right angles.

And yet we who live on the surface of the earth should not find anything new in Riemannian geometry because the geometry on the surface of a sphere cannot be Euclidean but must be Riemannian.

By definition, a straight line joining two points is the shortest distance beween these two points. Now the shortest distance between two points on a sphere is along the arc of the great circle joining the two points. Hence a 'straight' line on a sphere is a great cirele. Now it is not possible to draw a great circle parallel to a given great circle. One can draw a parallel small circle but not a parallel great circle. Thus if one tries to draw a parallel 'line' one does not get a great circle *i.e.*, one does not get a 'straight' line. Any two great circles on a sphere must intersect. There are no parallel great circles on a sphere and therefore there are no parallel straight lines in the geometry on a sphere. This geometry must therefore be Riemannian.

How is it then that we have been freely using Euclidean geometry in surveying and other practical measurements of distances on the surface of the earth? The foot-ball field on the earth is a plane and we draw straight lines as 'straight' and not curved like great circles. As a matter of fact, we use Euclidean geometry on the foot-ball field. But a foot-ball field is a very small—indeed insignificantly small—portion of the surface of the earth. On the other hand when the path of a non-stop airplane flight between two distant points on the earth is plotted, this path is invariably a great circle. The curvature of the sphere can be neglected when we consider only a small portion of the surfaee of the sphere and so this small portion could be regarded as flat and great circles in this flat osculating region become straight lines.

This analogy of the flat foot-ball field on the curved surface of the earth enables us to understand that particular property of Riemannian geometry which is useful in understanding Einstein's development of the invariant theory of gravitation. The Riemannian geometry on a large portion of the surface of a sphere reduces to Euclidean geometry when the size of the portion of the surface under consideration becomes small

This is a general property of Riemannian geometry. If in any region of space, the geometry is Riemannian, then in a small neighbourhood of a point in the region, the Riemannian geometry reduces to Euclidean geometry. One can express the same property in another

way. If in a region of space, the geometry is Riemannian, the region of space can be regarded as curved. At any point in this curved space we can choose a small neighbourhood in which the curvature of space is negligible and so the space in this neighbourhood can be regarded as flat and Euclidean geometry can be used there.

The Falling Lifts

Let us now return to the falling lift experiment of Einstein. We have found that the observer A in the falling lift finds that the path of the chalk-piece is a straight line, while the observer B on the ground finds the same path to be parabola. This situation is very much similar to our drawing straight lines on the foot-ball fields and great circles on large portions of the earth, both these being essentially straight lines of Riemannian geometry. There is a very simple word—*viz.*, the geodesic—to denote these straight lines of Riemannian geometry (*i.e.*, shortest path between two points of Riemannian space).

The geodesics on the curved surface of the sphere are great circles. In the foot-ball field these geodesics become straight lines. The observations of the falling lift suggest that the path of the chalk-piece must be a geodesic of Riemannian geometry. The falling lift can be likened to a small neighbourhood of a point (or to the foot-ball field on the earth) and so the geometry in this small region becomes Euclidean and the geodesics become straight lines. For the observer B, the curvature is not negligible and he finds the geodesics to be parabolas.

Let us pursue this suggestion a little further. We have mentioned above that the falling lift is a small neighbourhood of a point We should really say that it is a small neighbourhood limiting the experiences of the observer A. The smallness of this neighbourhood is judged in comparision with the region of experience of the observer B on the ground. Again this smallness does not refer only to the smallness in length, width and the height of the lift (the three dimensions of the lift) but also to the small time-interval to which the experiences of A are limited. The observations of A are not in a small lift but in a small falling lift. The smallness of the region of experience of A is not only in the 3 dimensions of space but also in the fourth 'time-dimension'.

Einstein's Law of Gravitation

We have seen above that the world of experience of an observer is 4-dimensional. The falling lift experiment clearly suggested that gravitation had to be linked up with geometry and that this geomery had to be four dimensional.

Einstein's law of gravitation requires that the geometry governing the observations in a gravitational field must be Riemannian. In other words, the four dimensional region of experience of an observer in a gravitational field is curved, the geometry being Riemannian Einstein gave a formula to find the curvature of the world of experience, depending on the masses producing the gravitational fields. If one takes a limited region of this world of experience (like the falling lift), the curva-

ture can be neglected and the Riemannian geometry becomes Euclidean.

Thus when the two observers A and B in the thought experiment of Einstein described gravitational phenomena on the basis of Newton's law their descriptions were different But when they describe the same phenomena on the basis of Einstein's law their descriptions become identical.

Mathematics and Sciences

Einstein's development of the invariant theory of gravitation clearly bring to light the important role which pure mathematics plays in the development of science. Euclid developed an axiomatic system of geometry. Scores of geometers after him attempted to replace some of these axioms and thus produce new geometries. Lobatchewsky and Riemann succeeded in developing two alternative geometries. One may just wonder—why this intense intellectual activity spread over some two thousand years. None of the mathematicians engaged in this activity had ever suspected that what they were discovering would some day be used in developing a theory of gravitation When a mathematician works out new disciplines in this subject he is working to satisfy his curiosity, his sense of abstraction and generalization; in short, he is developing mathematics for the sake of mathematics.

A scientist on the other hand is interested in observing, studying and understanding nature. In this process a stage comes when he has to look to disciplines developed by pure mathematicians to gain better understanding of nature. With this better understanding about nature the scientist proceeds to develop better methods of harnessing the forces of nature in the service of the society. In this way the contact is finally made with the man in the street.

While the scientist, in this way, goes on converting the mathematical developments into useful tools in the service of society, the pure mathematician goes on developing more and more pure mathematics tempting future scientists to develop more and more useful tools and in this way the caravan of progress remains continuously on the move.

The Solar Wind

W.I. Axford

THE solar wind is a highly supersonic stream of low density solar 'plasma' which moves almost radially from the Sun at all times; its existence has recently been confirmed by a number of space probes and satellites, notably Mariner II and Explorer XVIII (IMP-A). Some of the observed characteristics of the solar wind near the Earth's orbit are summarized in the accompanying table. Most of the ions in the plasma are protons (hydrogen nuclei) —usually 10 per cent—but with considerable fluctuations about this value

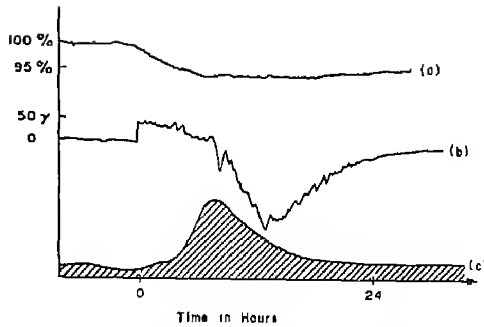


Figure 1. Characteristic features of a magnetic storm (a) Forbush decrease of the galactic cosmic ray intensity (b) The variation of the horizontal component of the Earth's magnetic field (c) The occurrence of aurorae

It is clear from observations in space and also by other less direct methods that the solar wind is by no means a steady phenomenon Sudden enhancements of the wind to velocities of 1000-2000 km per sec and densities of perhaps 30 proton-electron pairs per c.c are known to occur in association with solar flares, especially during the active phase of the 11-year sunspot cycle On encountering the Earth's magnetic field these enhancements cause magnetic storms and aurorae, and also produce variations in the cosmic ray intensity observed on the Earth (Figure 1).

Magnetic storms are manifested by particularly violent fluctuations of the magnetic field observed at the Earth's surface and by disturbances in the ionosphere which interfere with radio-wave reception The luminescence of the upper atmosphere which constitutes the aurora, appears to result from the penetration of solar wind particles into the polar regions of the Earth, although their path is not a simple one judging from the complicated pattern of many auroral displays. The most important variation of the cosmic ray intensity occurring at the time of magnetic storms is the Forbush decrease, named after its discoverer, Scott Forbush of the Carnegie Institute of Washington; this is probably due to the sweeping of cosmic rays away from the vicinity of the earth by the enhanced solar wind.

During the period of sunspot minimum, when flare activity is low, most of the increases in the solar wind flux appear to be associated with hot 'plage' regions on the Sun. These plage regions turn with the Sun in its 27-day periodic enhancements of the solar wind which are made evident on the Earth

Proton flux	10 to 10 per sq. cm per sec
Typical range of velocities	250-800 km per sec
Average velocity	500 km per sec (Mariner II, 1962) 400 km per sec (IMP-A, 1964)
Density	1 to 20 protons per cu cm
Temperature	1000000 to 5000000 °K
Typical proton energy	1 kev
Typical electron Energy	50 ev
Mach number of wind	5 to 10^{-1}
Magnetic field strength	5 gamma (5×10^{-5} gauss)

Table 1. Some observed characteristics of the solar wind near the Earth's orbit.

in the form of recurrent geomagnetic storms. Minor fluctuations in the solar wind flux occur at all times; there is some suggestion that this 'turbulence' was less pronounced during the period of the IMP-A observations than during the flight of Mariner II at a more active period of the sunspot cycle; however, this is not properly established at present. Several families of recurrent solar wind enhancement were observed by Mariner II, and it was also shown that the level of geomagnetic activity was rather well correlated with the solar wind velocity.

Since the beginning of the century it has been known that the Sun emits occasional bursts of particles which cause magnetic storms and aurorae on interacting with the geomagnetic field. However, until quite recently it was believed that these particles were confined to rather distinct beams which constituted anomalies in the interplanetary medium as a whole. Sydney Chapman, for example, considered the interplanetary medium to be the static extension of the solar corona, while Fred Hoyle and others thought it might consist of inflowing interstellar gas attracted by the Sun's gravitational field.

The first suggestion that the emission of particles by the Sun is a more

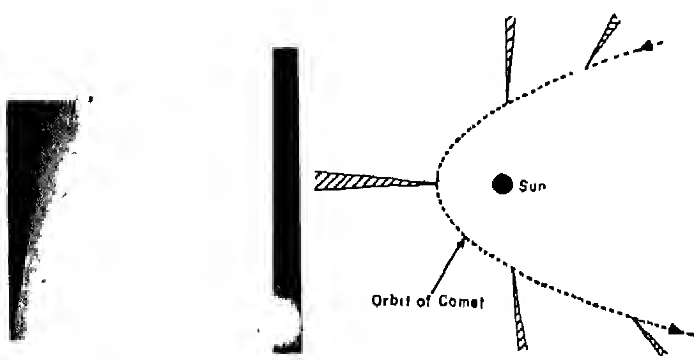


Figure 2. (a) An example of a type-1 comet tail (Halley's comet, 4 May, 1910; the other big object is the planet Venus) (b) Typical behaviour of a type-1 comet tail during passage of the comet around the Sun. The tail extends more or less radially away from the Sun at all points in the orbit.

general phenomenon which persists at all times and effectively constitutes the interplanetary medium, was made by Ludwig Biermann in 1951 on the basis of arguments concerning the behaviour of the gaseous (Type I) comet tails. These comet tails point almost directly away from the Sun irrespective of the motion and position of the comet (see Figure 2). It was previously accepted that this was due to the pressure of sunlight. However, the acceleration of visible features in the comet tails is found to be much too rapid to be adequately explained on this basis, and one is therefore forced to consider the possibility of streaming particles as the main cause.

The evidence of the comet tails suggests that this outflow from the Sun occurs at all times, even at sunspot minimum when the Sun is least active. The particles also appear to travel in all directions away from the Sun, although with possibly diminished intensity from the polar regions. Additional evidence for continual corpuscular radiation can be deduced from the observations that the Earth is never entirely free of magnetic disturbances and that the polar aurora occurs to some extent at all times.

Biermann's suggestion was taken up by E.N. Parker of the University of Chicago, to whom we owe the name 'solar wind'. Parker made an essentially simple mathematical model which showed that the solar wind is a direct consequence of the hydrodynamic expansion of the hot solar corona into the near vacuum of surrounding space. He has also made it clear that since the corona is too hot to be confined by the Sun's gravitational field, the earlier view that the interplanetary medium is largely a static extension of the corona is untenable.

The solar wind cannot extend indefinitely far from the Sun, but eventually should be stopped by the interstellar medium It is believed that when the ram pressure of the solar wind is sufficiently attenuated by spreading through a large volume of space and becomes comparable to the inward pressure of the interstellar medium, a standing shock wave occurs This causes the wind to become subsonic by reducing its bulk velocity at the same time as increasing the random motions of the individual particles. The material is then able to cool by mixing with the interstellar gas and it gradually disperses and becomes part of the interstellar medium, as sketched in Figure 3.

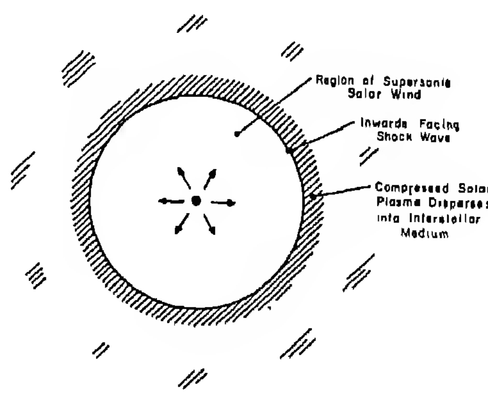


Figure 3. Interaction of the solar wind with the interstellar medium. The solar wind is supersonic and moves radially outwards within a roughly spherical cavity of radius about 50 times the Earth-Sun distance Beyond the shock wave which forms the cavity boundary the solar plasma cools and mixes with the interstellar medium.

The average size of the cavity in which the solar wind remains supersonic has been estimated to be about 50 times the Earth-Sun distance, which is roughly the extent of the known system of planets, however, this figure might be in error by a factor 3. One would expect the cavity to be larger at sunspot maximum than at sunspot minimum due to increased solar wind pressure, and it has been suggested that herein lies the cause of the eleven-year variation of the intensity of galactic cosmic rays (Figure 4i) The solar wind tends to blow cosmic rays away from the sun, and so the cosmic rays should be pushed out of the inner solar system more effectively at sunpot maximum than at sunspot minimum as indicated in Figure 4ii

Perhaps the most interesting aspect of the solar wind is its interaction with the geomagnetic field. The latter is confined by the flowing plasma into a tear-drop-shaped region which at altitudes greater than 100 km above the Earth is termed the 'magnetosphere' (Figure 5). The sunwards side of the magnetosphere is blunt, its shape being largely determined by a balance between the external solar wind pressure and the pressure of the Earth's magnetic field in the interior. The downstream 'tail' of the magnetosphere probably extends far beyond the orbit of the Moon to perhaps several million kilometres. Further downstream a wake of some sort should occur, and it is expected that this will be observed by Mariner IV as it passes behind the Earth on its way to Mars early this year.

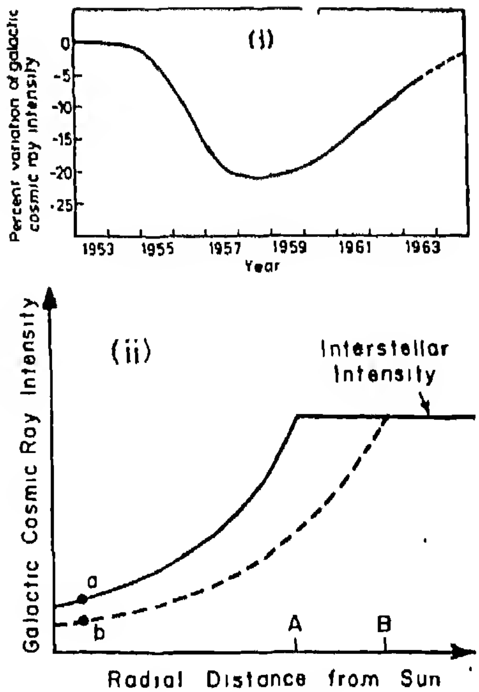


Figure 4. (i) Percentage variation of the galactic cosmic ray intensity at a typical mid-latitude station (1954, 100 per cent). Note that minimum intensity occurs roughly at sunspot maximum (1958-59). (ii) Possible explanation of the effect shown in (i). The solar wind causes a reduction of the intensity within the cavity sketched in Figure 3. At sunspot minimum the cavity is smaller (A) than it is at sunspot maximum (B), giving a corresponding variation of the cosmic ray intensity (a-b) at the Earth.

The tail of the magnetosphere appears to be more than a mere shadow zone, for the characteristics of the Earth's magnetic field in this region suggest that it has been dragged out by the solar wind, implying that some viscous-like mechanism is operative. Many features of the magnetic storm phenomenon, especially the aurorae, represent essentially dissipative processes,

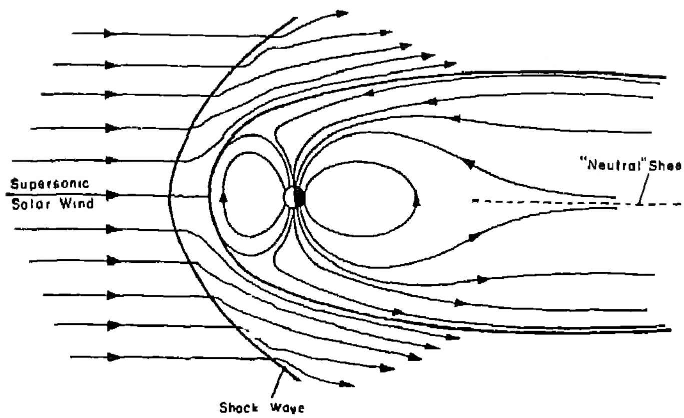


Figure 5. Flow of the solar wind around the magnetosphere, showing the bow shock wave produced in the upstream side of the magnetasphere, and the extended 'tail' formed by the downwind portion of the magnetosphere Note the tendency for oppositety directed field lines to lie next to each other in the tail, giving a 'neutral' sheet

and there is a strong body of opinion which considers this dissipation to be associated with the viscous-like component of the solar wind-magnetosphere interaction and hence with the formation of the tail.

In particular the 'neutral sheet', a region of low magnetic field strength which separates the incoming and outgoing field lines in the tail, has been predicted to contain a relatively high flux of energetic electrons. It has been suggested that these particles are ultimately driven towards the Earth where they are mostly precipitated into the atmosphere to produce aurorae, although some escape and contribute to the Van Allen radiation belts surrounding the Earth. Until quite recently there has been very little information concerning the tail; however, observations from Explorer XIV and IMP-A have shown that the magnetic field configuration of the tail is indeed as indicated in Figure 5. There are also indications from early Russian Lunik observations and lately from the Vela Hotel satellites that there are substantial electron fluxes associated with the 'neutral sheet'.

An important feature predicted for the solar wind-magnetosphere interaction is that a standing shock wave occurs on the upstream side of the magnetosphere, similar to the bow shock wave ahead of a re-entering missile or to the bow wave of a tugboat. This causes the solar wind to be brought almost to rest and the protons to share their energy with the electrons. The excellent IMP-A observations have confirmed the existence of this shock wave and constitute the first unambiguous, observations of the so-called 'collision-free' type of shock wave which is

predicted to occur in low density plasmas when the particle mean free path is very large. The possibility of such a collision-free shock was first suggested more than a decade ago by T. Gold, who pointed out that the sudden onset of geomagnetic storms requires a relatively thin shock to precede the plasma ejected from a solar flare. In fact, a shock wave of this type propagating through the interplanetary medium was observed by the Mariner II plasma and magnetic field detectors.

It is fair to conclude that the remarkable progress that has been made in the last few years has led us to the verge of a complete explanation of the auroral and magnetic storm problems. The behaviour of comet tails and cosmic rays as well as many other phenomena are also becoming understood.. There is an additional bonus in detailed information concerning plasma processes, which cannot possibly be obtained from the relatively dense, shortlived, and usually contaminated plasmas that are produced in the laboratory.

Madame Marie Curie - Radioactivity and Atomic Energy

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As late as 1895 physicists and chemists seemed to be convinced that the ultimate particles of matter consist of atoms which cannot be further broken down In 1896 a new phenomenon, *i e.*, radioactivity, was discovered by Henri Becquerel (1852-1908) of France, which changed our ideas regarding the ultimate particles of matter The discovery of X-rays by Prof. Rontgen (1845-1923) in 1895, of cathode rays by J. Plucker (1801-1868) and others also helped in modifying the scientists' notion regarding the atom.

Prof Becquerel was the Head of the Physics Department of the Natural History Museum in Paris and was an authority on fluorescence of uranium compounds He exposed a fluorescent potassium uranyl sulphate crystal to sunlight and then placed it on a photographic plate wrapped in black paper and observed an image of the crystal on the photographic plate when it was developed. In the next few days there was no sunlight in Paris and Becquerel put the crystal over a photographic plate wrapped in black paper. In this case also an image of the crystal appeared on the plate. He reported to the French Academy of Sciences in February 1893 (Compt. rend. **122,** 420; 24 February, 1896) that this salt, 'must emit radiations which are capable of passing through paper, opaque to ordinary light'. He also observed that the same effect was produced in the dark and by other uranium compounds, and the radiations given out by uranium made a gas conduct X-rays and cathode rays. This was the discovery of the radioactivity of uranium, which is spontaneous decomposition of matter into smaller particles. This subject of radioactivity was greatly advanced by Madame Curie with the help of her husband, Pierre Curie, because they made the capital discovery that a very highly radioactive material, which was named radium, was present in the mineral pitchblende even after the removal of uranium compounds. Radium decomposes spontaneously and much more vigorously with liberation of heat and other radiations than the uranium compounds. This discovery made it possible for man to visualize the production of energy by the breaking of atoms.

Marya (Marie) Curie was the daughter of a Polish Professor Sklodovska and was born at Warsaw on 7 November, 1867. As Poland was backward in science at that time, she had to learn science from books; but, in 1890 she could carry on some elementary experiments in physics and chemistry in her cousin's laboratory She wanted to study science in the

great centre of learning, Paris, and had to save money for this purpose by serving as a governess for about six years. She joined for a short while her sister and brother-in-law at Paris. Soon afterwards she shifted to cheap lodgings and registered herself for Licence Degree in Science Faculty, University of Paris, Sorbonne, in 1891 She obtained first position in Licence in physics in 1893 and second position in mathematics in 1894 whilst living in Paris under great privations. In 1893 she carried on some research work on the magnetic properties of steel under Prof. G. Lippmann, a Nobel Laureate in Physics and came in contact with Prof. Pierre Curie of the *Ecole de Physique et de Chimie*, Paris, a great authority on magnetism.

From 1896 she carried on the chemical analysis of numerous uranium minerals found in Prof. Becquerel's Institute and other laboratories in Paris and made a striking observation that the uranium content of these minerals and their power to discharge a charged gold leaf electroscope do not go hand in hand. The power to discharge a gold leaf electroscope, which is caused by the radioactivity of the minerals and the ionisation of the surrounding air, may be large, specially of pitchblende, even after the separation of uranium. By that time, that is in 1895, she was married to Prof. Curie who realised the importance of the investigations undertaken by his wife and joined her in these researches. The husband tackled this problem from the physicist's point of view and concentrated on the determination of the properties of the radiations given out He and others proved that the radiations emitted by radioactive bodies consist of α-particles, positively charged, consisting of helium, β-rays which are negatively charged and γ-rays, similar to X-rays, are given out. Madame Curie devoted herself to the chemical manipulation of separating large amounts of extraneous substances dealing with one ton of pitchblende supplied by the Austrian Government from which uranium was separated In April 1898 she came to the conclusion that pitchblende contains an unknown element, much more radioactive than uranium The problem was to separate the active material from pitchblende by chemical group separation and fractional crystallization. The radioactivity of the products was determined by the electrometer method. The laborious and the tedious chemical separation was undertaken by Madame Curie. One evening after returning to their laboratory in the *Ecole de Physique et de Chimie*, the Curies were pleasantly surprised to find that their radioactive products were emitting light in the dark room.

Discovery of Radium by Pierre and Madame Curie

In June 1898 a radioactive element was obtained in bismuth sulphide precipitate and was named polonium after the name of the motherland of Madame Curie. In December 1898 the discovery of radium in the barium sulphate precipitate was announced. This impure radium preparation showed a radioactivity which was million times greater than that of uranium.

A third radioactive element was discovered in the ammonium hydroxide precipitate containing ferric and rare earths compounds by A Debierne in 1900, who was helping Pierre and Madame Curie They called this product actinium, which was also independently discovered by O. Giesel (1852-1927), who was a chemist in a quinine factory in Brunswick. It has been reported that Giesel also prepared and sold radium bromide and his own breath was found to be radioactive, although he lived over 25 years after the discovery of actinium. Madame Curie presented her thesis for the D.Sc. degree in the Sorbonne in 1902 embodying her researches on radium and radioactivity, and the same was published in the following year. In 1902 she determined the atomic weight of radium by precipitating 0.09 of radium chloride with silver nitrate and obtained a value of 225 as the atomic weight of radium. Again, in 1907, working with 0.4 of radium chloride, she found the atomic weight to be 226.4 taking silver as 107.88 and chlorine 35.46. The eminent authority on determination of atomic weight, Prof. Honigschmid of Vienna, in 1911, obtained a value of 225.95. Aston's mass spectrograph indicated the value as 226.1. The accepted value today is 226 05. In 1910 Madame Curie and Debierne isolated metallic radium by electrolysing a solution of radium chloride with a mercury cathode The mercury was separated from the amalgam by distillation.

Radioactivity was intensely studied all over the world, specially by Rutherford (1871-1937) in Canada and England, Soddy (1877-1956), Fajans, Boltwood, O. Hahn and others Rutherford studied the activity of uranium and thorium and reported in 1899, that the rays emitted by uranium were of two kinds (i) those stopped by thin sheets of aluminium which he called α-rays, and (ii) the other requiring much thicker sheets of aluminium designated as β-rays, which are deflected by a magentic field

Madame and Pierre Curies reported in 1900 that β-rays carry a negative charge Becquerel, in 1900, by deflection in electric and magnetic fields determined the velocity (1.6 x 10^{10} cm. per second) and the ratio of charge to mass ($e/m = 3 \times 10^{17}$ e.s.u/g of β-rays). These values are of the same order of magnitude as those for cathode rays Strutt (4th Baron Rayleigh) in 1901 and Crookes in 1902 suggested that α-rays were positively charged particles of relatively large mass. This was confirmed by Rutherford in 1903 Villard discovered the rays which were called γ-rays by Rutherford. They are more penetrating than β-rays and not deflected by magnetic field.

In 1910 Madame Curie could prepare one gram of radium from pitchblende after great efforts and presented this valuable material to her laboratory. In 1920 she was invited by the women of America and many honorary degrees and distinctions were showered upon her, and the women of America subscribed for the purchase of another gram of radium for her institute.

Madame Curie, First Woman Professor of the Sorbonne and twice Recipient of the Nobel Prize

In 1903 the Davy Medal of the Royal

Society of London was awarded to Professor Pierre and Madame Curie. The Nobel Prize of 1902 in Physics was first awarded to Prof. Becquerel and Pierre Curie, who represented to the Nobel Committee that the discovery of radium was as much due to him as to Madame Curie, and, the Committee agreed to award half of the Nobel Prize to the husband and the other half to the wife. In April 1906 Pierre Curie was killed in a street accident in Paris. The authorities of the University of Paris appointed Madame Curie as Pierre Curie's successor to the Chair of General Physics at the Sorbonne. This was the first time that a woman was appointed as University Professor. In 1911 Madame Curie was awarded the Nobel Prize in Chemistry. Thus she was the only recipient of the Nobel Prize twice in science.

Since 1900 the physiological effect of radium rays was investigated by the Pasteur Institute of Paris and the Paris University jointly established a radium institute known as Pavillon Curie with Madame Curie as the Director of Physical Sciences, which was ready for occupation in July 1914-1918. Madame Curie installed X-ray equipment for military purposes in 20 motor cars and 200 hospitals in different parts of France for the treatment of the wounded.

From her research institute 483 scientific communications of which 34 were theses and 31 publications in the name of Mme Curie appeared during the period 1919 to 1934. Doctor Regaud, Director of the Biology and Medicine Branch of the Pavillon Curie treated 8319 patients from 1919 to 1935. Baron de Rothschild and Lazard Freres and an annonymous donor contributed 3.5 million francs to the Curie Foundation.

Life Pension Sanctioned by French Government in 1923

On 26 December, 1923, i.e., 25 years after the discovery of radium, the French Government voted 40,000 francs as annual pension to Madame Curie with the right of inheritance to her daughters Irene and Eve.

Prof. Regaud wrote: 'Madame Curie can be counted among the eventual victims of the radioactive body which she and her husband discovered'.

Death of Madame Curie Caused by Radioactive Emanations

In 1934 she became seriously ill and proceeded to the Sancellemoz Sanatorium where she died. The Officer-in-Charge, Doctor Tobe recorded: 'The disease was a plastic pernicious anaemia of rapid, feverish development. The bone marrow did not react, probably because it had been injured by a long accumulation of radiation.' Due to constant exposure to the highly toxic rays from radioactive substances investigated by them, Irene and her husband also died prematurely.

Madame Curie — a brilliant Director and Lecturer

Prof. Einstein stated: 'Marya Curie is of all the celebrated beings the only one whom fame has not corrupted.'

I had the honour of working in her institute for two years: 1917-1919, and I

found that she took great pains in preparing university lectures with experimental demonstrations in which her daughter Irene helped her. After receiving the Nobel Prize with her husband, Prof. Curie Joliot, Irene visited different countries and visited India in 1950.

Prof. Jean Perrin, the Nobel Laureate, who was also my teacher, frequently stated: 'Madame Curie is not only a famous physicist, she is the greatest laboratory director I have ever known.' During this period a galaxy of brilliant mathematicians and scientists, Henri Poincare, Appel, Painleve, Le Chatelier, Bouty, Lippmann, Haller, Behal, G. Bertrand, Roux, Delepine, Caullery, Urabain, Langevin, Duclaux, Job, Matignon, Jungfleisch, Pierre and Madame Curie, Mouton, Fabry, D. Berthelot, Moureu, Dufraïsse, Grignard, Fourneau and others were teaching in Paris.

ATOMIC DISINTEGRATION

The collision of fast α-particles, protons, deuterons or neutrons with atoms of other elements may cause the breaking of the nucleus. Rutherford reported in 1919 and 1920 that nitrogen exposed to α particles emits long range protons which came from the nitrogen nucleus. Similarly, Rutherford and Chadwick in 1921, Blackett in 1922 and Harkins and Ryan in 1923 demonstrated the disintegration of atoms by the cloud chamber method. When α-particles having mass 4 and charge 2 bombard nitrogen atom, mass 14 and nuclear charge 7, they enter the nucleus producing a particle of mass 18 and nuclear charge 9, which is an isotope of fluorine. This nucleus emits a proton, mass 1 and charge 1, producing a nucleus of mass 17 and charge 8, which is an isotope of oxygen. In 1932, Cockroft and Walton disintegrated lithium into helium. This was the first artificial atomic disintegration by bombardment with high energy protons from hydrogen ionised in a discharge tube and accelerated by high potential difference In 1933, F. Joliot and Irene Curie observed that both positive and negative electrons are emitted by thin layers of berylium, boron and aluminium bombarded by particles from polonium. In 1934, they reported that the emission of positron persisted after the removal of the source of α particle. This was the first discovery of artificial radioactivity.

Fission of Uranium to Barium by Otto Malhn and Influence of Chemical Evidence in Fission.

E. Fermi and collaborators, by bombarding uranium, atomic number 92, with slow neutrons obtained by passing through water or paraffin wax, thought that they had obtained an element of atomic number 93. They reported similar results with thorium in 1934, but Frau Ida Noddack criticized Fermi's chemical evidence and stated: 'It is conceivable that in the bombardment of heavy nuclei with neutrons, these nuclei break up into several large fragments which are actually isotopes of known elements, not neighbours of irradiated elements.' O Hahn and Strassmann in 1938, by co-precipitating the solution of the product of the bombardment of uranium with neutrons with a barium

salt solution, thought that they had obtained an isotope of radium. After β-ray decay, the products of the bombarded material were precipitated with lanthanum. Hence, the authors regarded them as the actinium isotopes. Mme Joliot Curie and Savitch, in 1937, reported that the bombarded product concentrated with lanthanum rather than with actinium.

Early in 1939, Hahn and Strassmann concluded that their supposed radium was actually barium, and from chemical evidence they concluded that their actinium and thorium were really lanthanum and cerium. The authors stated that their experimental results contradicted the accepted views in nuclear physics. Lise Meitner, who was a collaborator of Prof. Hahn for a number of years in Berlin, and O.R. Frisch, in 1939, reported that nuclear physics must give way to chemistry and stated: 'On the basis of present ideas about the behaviour of heavy nuclei, an entirely different and essentially classical picture of these new disintegration processes suggests itself. It seems possible that the uranium nucleus has only small stability of form and may, after neutron capture, divide itself into two nuclei of roughly equal size.

It was soon discovered that the fission of uranium by neutrons liberates a large amount of energy according to Einstein equation: $E=MC^2$ where E= energy liberated; M=mass destroyed and C=the velocity of light. Both isotopes of uranium U_{235} and U_{238}, are split by fast neutrons but U_{235} is broken up by slow neutrons. In this process, more neutrons are liberated, but the fast neutrons escape quickly and it is only the slow neutrons which are effective for breaking U_{235} and the creation of an atomic bomb.

Discovery of Transuranium Elements

In modern times increasing neutron fluxes are being achieved as nuclear reactors are improving and 12 new elements beyond uranium have been isolated. The first four of these transuranium (94), americium (95) and curium (94), americium (95) and curium (96) can be manufactured in kilograms whilst californium (98) in grams. The chemistry of berkelium (97) has been studied with submicrogram amount and, hence, this element along with einsteinium (99), fermium (100), has only been obtained in traces. The elements upto fermium (100) are formed from uranium 238 by succession of neutron capture and β-ray decay as shown by the reaction leading to the discovery of neptunium and plutonium.

It has been found that elements of atomic number of 100 or more decay by spontaneous fission with very short half life, so that their preparation cannot be achieved by exposing uranium or transuranium elements to a reactor or more rapidly by exploding a thermo-nuclear device in a suitably sealed underground cave and processing the debris. Such elements are prepared by bombarding plutonium, curium or californium with boron, carbon, nitrogen, oxygen or neon ions accelerated in a cyclotron or linear accelerator. The yields of mendelevium (101), nobelium (102), lawrencium (103) and element 104 are extremely

small. Along with transuranium elements, fair amounts of technetium (43) and promethium (61) are formed as fission products in nuclear reactors. Polonium 210 and actinium 227 can be readily synthesized by neutron irradiation of bismuth and radium respectively.

Atomic Fission Markedly Increases Production of Highly Dangerous Radioactive Materials

Before the fission of uranium by neutron in 1939, the amount of radioactive matter in use in the hospitals and laboratories throughout the world was only equivalent to a few hundred grams of radium of atomic weight 226. Today, a low power (10 megawatt) nuclear reactor fed with natural uranium will produce fission products giving out α–radiations equivalent to one ton of radium together with α–particles emitting transuranium elements equivalent in activity to 200 grams of radium. The generation of large amount of radioactivity is highly hazardous and the investigations of the chemical properties of the new elements are not straightforward because of their radioactivity, which is more intense for the higher elements. The radiations emitted have two important consequences relating to health hazard and to their chemistry. The first is that they are among the most toxic substances known to man because of the irreversible damage to tissue caused by such materials. When ingested, they are selectively retained in critical organs in the body. Plutonium, for example, tends to concentrate in the bone; other elements in the series are retained in the kidneys or in the gastro-intestinal tract. The high toxicity becomes immediately apparent when one compares the maximum permissible concentrations per cubic metre in air for continuous exposure, assuming a 40-hour week with those for the more conventional poisons. The figures for carbon monoxide and hydrocyanic acid are 100 mg. and 10 mg. respectively while those for ^{239}Pu and ^{241}Am are 3.1 x 10^{-8} mg. and 1.8 x 10^{-9} mg respectively many orders of magnitude smaller than those for hydrocyanic acid.

Chemistry played a major part in the discovery of fission process by identifying barium as one of the products of thermal-neutron bombardment of uranium. Chemical processes have also played an essential role in the application of the fission process to the production of nuclear power. These processes involve the treatment of several thousand tons of uranium per annum, this tonnage is comparable to that of the metals, mercury and silver, substantially lower than elements such as arsenic, tin and nickel, yet rather larger than gold, beryllium and tantalum.

Two sequences of chemical processes are involved. In the first, ore concentrates (largely U_8O_3) are converted to nuclear fuels. uranium metal or dioxide. In the second, the nuclear fuels, after removal from reactors, are treated for the recovery of useful constituents, such as plutonium or fission-product strontium. The radioactivity in the first category is relatively low, but in the second very high.

Thorium as Fissionable Material

Since the application of uranium in

atomic fission as a power source has been developed to such an extent, attention has been directed to thorium which is more abundant in nature than uranium, as a possible source of the secondary nuclear fuel U^{233}. According to J. Paone (1960) an important potential use of thorium is its application in the field of nuclear energy. By the capture of slow neutrons Th^{232} is converted to Th^{233} a negative beta particle being emitted with a 23-minute half life The product of Th^{232} is protoactinium, which is also beta active with a half life of 27.4 days. It decays into fissionable U^{233} and a long lived α–particle with 1.63×10^5 years half life. Thus, the thorium nucleide, upon bombardment by thermal or slow neutrons, becomes eventually a potential nuclear fuel material capable of initiating a chain reaction. Nuclear reactions employing a blanket of thorium around the reactor are capable under certain conditions of producing as much and possibly more fuel than is consumed in fission. A number of major reaction projects proposing to use thorium have been under way for several years in the USA.

Atomic Energy not yet in The Picture of World Energy Sources

The discovery of the neutron fission of uranium to barium and other elements in 1939 by Prof. Otto Hahn with liberation of tremendous energy has led to fabulous activity and expenditure all over the world for obtaining atomic energy for the use of man. But, uranium occurs on the earth's surface to the extent of 4 grams per ton of the earth's crust, whilst thorium, another fissionable element, is three times more abundant. Moreover, 0.7% of natural uranium is uranium 235 which actually breaks up in energy production Although, 12 new transuranium elements have been synthesized in the last 26 years, the consensus of expert opinion seems to be that even on the basis of the most optimistic assumption about the future rate of nuclear developments, the contribution of atomic power until 1975 to growing energy demonds will be marginal. (*The Petroleum Handbook*, 4th edition, London, 1959, page 20.)

'Nuclear power offers no panacea for the world's energy problems. The adoption of fission power will be slow and its rate will depend ultimately on the exhaustion of fossil fuel reserves. Fusion power, while potentially having many advantages over fission power including an inexhaustible fuel supply for negligible cost, has not yet been established as feasible and its costs cannot be reliably assessed. Both types of nuclear power are uniquely adapted to the generation of electrical power and less so to the production of other forms of energy, such as those now used in comfort and process heating or in land transportation. Thus, a radical change in existing energy consumption patterns is required before the fossil fuels are finally exhausted.' (Robert C. Axtmann, pp 488-495 in *The Population Crisis and the Use of World Resources*, edited S. Mudd, 1964, The Hague, Dr. W. Junk, Publishers).

Beginning of Atom Bomb

After the beginning of the Second World War in 1939, Prof. Otto Hahn of Berlin approached Hitler and informed

him that he was in a position to manufacture a powerful bomb from his discovery of atomic fission. Hitler asked him how much time he would take for this purpose and Hahn replied that it would take two years But, Hitler was impatient and he stated that he had no use for a discovery which cannot produce tangible result within six months.

On the other hand, after the occupation of Denmark by Hitler, Neils Bohr, the great Danish atomic physicist had to leave his own country for USA as he was a Jew. But, before he left Denmark, he discussed the details of atomic fission with Lise Meitner who was associated with Hahn in atomic fission studies and who being a Jewess was on her way to Sweden from Berlin. After reaching USA, Bohr contacted A. Einstein, who also was of Jewish origin and a Professor in the Princeton University as a naturalised American citizen. These two great men discussed the fibrication of the atomic bomb and Einstein wrote to President Roosevelt to take up this work. Roosevelt consulted Churchill, the Premier of the United Kingdom, who was encouraged by Lord Cherwell (Prof. Lindemann), Churchill's scientific adviser. Also, Churchill sent some of his able atomic physicists, mathematicians and engineers to join the USA experts. This tremendous undertaking, which was extremely difficult in execution, resulted in the construction of atomic bombs under the leadership of R. Oppenheimer, another Jew from Germany and settled in the USA. Under the Presidentship of Truman, the two bombs fell on Hiroshima and Nagasaki in 1945, and, thus, began the atomic age with all its complications and dangers.

Bio-Electricity Made Visible

Alfred De Waart

IF you had visited the Dutch town of Leiden during a certain period at the beginning of the present century, you might have been surprised to see cables stretched across the street and linking a hospital with a building a mile or so away. In that building was housed a galvanometer which was difficult to transport (hence the cables). The arrangement which you would have witnessed contributed to research on sufferers from heart disorders, research which has since become world famous and which led to the award, in 1924, of a Nobel Prize to the Dutch physiologist Dr Willem Einthoven.

Electrical phenomena associated with the working of the human heart (and for that matter, of other organs) enable a detailed insight to be obtained into the functions and disorders of the heart, its position in the body, its behaviour during anaesthesia and operations, its reactions to medicines, breathing, oxygen deficiency, muscular effort, vitamin deficiency, and many other conditions.

This research into the electrical phenomena of life, or bio-electricity, could not have reached the present-day degree of development and application had it not been for the basis which Willem Einthoven laid at the beginning of the century.

Einthoven was born at Semarang, on the northern coast of the island of Java

Dr. Willem Einthoven

in 1860. His father was then an army doctor who later became Municipal Health Officer in the town. Einthoven Sr. died when his son was only a young boy. When the latter was ten, the family moved to Holland and Willem commenced his medical studies at Utrecht Dr. Willem Einthoven.

Even in his student days he showed himself to possess exceptional talents, not only in the field of medicine but also in those of mathematics and physics. He published the result of his anatomical

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The recording of bio-electrical phenomena, as developed by Willem Einthoven, Dutch physiologist and Nobel Prize Winner. By courtesy: Royal Netherlands Embassy, New Delhi.

and physiological investigations. Above all he was interested in the functions of the human eye, and in the early stages he was determined to specialize in opthalmology

In 1885, Einthoven wrote a very important thesis on 'Stereoscopy by colour difference', in which he provided an explanation of the remarkable fact that objects of varying colour situated at the same distance from the eye may wrongly be judged to be at different distances. His ingenuity in disproving a generally accepted theory by his teacher, Prof Donders, not only resulted in Einthoven graduating *cum laude* as Doctor of Medicine, but also in his being offered the chair of physiology at the University of Leiden despite the fact that he was then not even 25.

It was not long before that the young doctor devoted himself to electrophysiology, the study of electrical phenomena of life. This involves the registration and measurement of the differences of potential or currents developed in living organs during their functions. This is achieved by connecting the organs directly or indirectly to suitable recording and measuring equipment.

For detailed examinations, such measuring instruments must comply with very stringent requirements because often they are required to handle very minute and rapidly changing potentials. Thus the instrument must be highly sensitive, possess negligible inertia and yet adequate damping and must permit small deflections to be recorded at large magnifications, preferably by means of photography.

At the time of Einthoven's experiments, instruments of this calibre had not been invented There was, however, the capillary electrometer developed by Lipmann in 1873. Einthoven studied the physical properties of this instrument and although it displayed inadequacies for the type of work, it was the first which Einthoven used to obtain records of the electrocardiogram (E.C.G.) and the heart sounds in both healthy persons and heart sufferers He was fully aware of the fact that the graphs produced with the aid of Lipmann's instrument were greatly distorted, and that, time-wasting mathematical corrections were necessary in order to arrive at the desired result. With the aid of such corrections, he was able to calculate and construct exact E C.G s, but the method did not satisfy him. His main desire was to put all his efforts into the development of a new measuring instrument which did not possess the shortcomings of the capillary electromotor, and which would be able to provide immediately a really accurate record of the human E.C G.

With this thought in mind, Einthoven embarked on several years of study and experiment which eventually resulted in the development and construction of his string galvanometer. He described the principles of this instrument in 1901, and gave further details eight years later. The first really exact human electrocardiogram obtained with the aid of this string galvanometer was published by Einthoven in 1902

The string galvanometer utilizes the fact that a conducting fibre centred in a

magnetic field starts to move as soon as an electric current is passed through it. The bio-electrical phenomena (the currents developed by the heart and other organs during their functions) are passed, in this instrument, through a very delicate fibre consisting of quartz coated with silver or gold and stretched like a string in the centre of an electromagnetic field. The resulting small, rapid deflections of this fibre are optically magnified and then photographed. The physical properties of the instrument may be easily altered by varying the tension of the fibre to give less rapid deflection with increased sensitivity, or *vice versa*.

Einthoven was not merely the first man to record accurately the human electrocardiogram using his own instrument. He also pointed out the necessity for international standardization of the method employed in electrocardiography and of choosing the same points on the surface of the body from which to take the conducting wires of the galvanometer in order to measure the heart current.

With his experiment involving the use of cables stretched across the streets of Leiden, Einthoven not only inaugurated the era of tele-cardiography but also that of phonocardiography—the study of heart sounds picked up by microphone and then transformed into electrical vibrations.

Again with the aid of his string galvanometer, Einthoven studied the production of electricity in the human eye and the functions of certain nerves including the electrical phenomena which occur in the skin under the influence of emotions. By using extremely fine, short quartz fibres in a vacuum (the vacuum galvanometer) he achieved even more detailed results. These in-

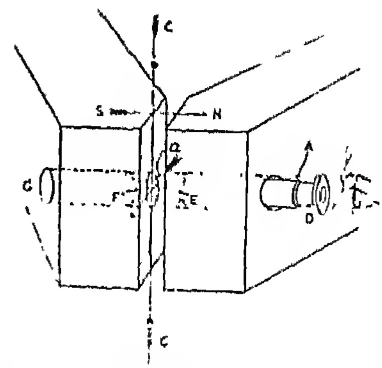

Diagram illustrating the principle of the string galvanometer

N and S poles of electromagnets CC quartz string
GFEG optical system for projection of string shadow.

cluded the photographic registration of wireless telegrams transmitted between Leiden and Banding, a distance of some 8,000 miles. This experiment was carried out in cooperation with his son.

The development of radio technology, and above all the birth of radio valves capable of high amplification of minute electrical tensions, made it possible to employ less sensitive and differently constructed equipment, which had moreover the advantage that it was no longer immovable. Gradually the

electrocardiographs as we know them today came into existence, and these included types capable of registering the electrocardiogram directly on paper. The latter was greatly appreciated by practising doctors since it omitted the time-consuming photographic procedure.

Einthoven did not live long enough to follow these technical developments to maturity. He died in Leiden in 1927 at the age of 67. He did, however, issue a warning against the danger that the use of radio valves in electrocardiography might result in distortion and thus affect the final result. Barron issued a similar warning in 1952, and added that it would be of value if the performance of modern instruments were subjected to regular comparison with the results obtained with the aid of the string galvanometer, whose reliability was firmly established.

Einthoven created a true centre of international cooperation. In his dealings with others he displayed not only enormous scientific abilities but also showed that he had heart and conscience, with the result that working with him was a pleasure. He was loath to discuss his work and always gave to others the credit which they deserved In a speech following the presentation to him of the Nobel Prize in 1924, he was noticeably lavish in his praise of Sir Thomas Lewis of London, with whom he had worked and who had made a major contribution to the knowledge of electrocardiography, both as a result of his experiments and of his clinical work.

Still greater advances in electronics made it possible to apply radio transmitting equipment to the field of E.C.G. The patient carries a tiny transmitter with him from which his heart currents are sent out, to be picked up by a receiver located elsewhere. The necessity of direct wire connection with the electrocardiograph is thus a thing of the past. Not only is this system used in operation theatres, but it has also been successfully applied in measuring ON EARTH the heartbeats of astronauts circling in their capsules hundreds of miles out in space.

Central Scientific Instruments Organisation

Around the Research Laboratories in India

AN inter-departmental meeting, in which representatives of the Ministries of Heavy Industry, Production, Steel Mines and Fuel, Defence and Consumer Industries, Communication, Education, and the Council of Scientific and Industrial Research participated, was held on 23 April, 1957, on the recommendations of the panel of scientists of the Planning Commission, which met earlier to formulate specific proposals for the development and manufacture of scientific instruments of different types in the country. At this meeting, a committee was set up with Prof M.S. Thacker, Director-General of the Scientific and Industrial Research, as chairman to draw up the requirements of scientific instruments required by schools, colleges, technical institutions, research centres, industry, the Ministry of Communication, as well as draw a scheme indicating the defence instruments to be manufactured at public factories.

On the recommendations of the above committee, the Central Scientific Instruments Organisation was set up in October, 1959 under the CSIR. The activities of the new organisation were to include survey, assessment, rationalization, standardization, design, development and indigenous manufacture of scientific instruments and provision of training facilities for workers required by the industry.

Although Chandigarh was selected as the venue of the organization, the Central Office of CSIO continued to be in New Delhi till Dr. P.S. Gill took over as Director from Dr. K. N. Mathur in September, 1963. During this period, the CSIO was able to make arrangements for collaboration with the United Nations Technical Assistance Board for setting up the CSIO and with Swiss Foundation for establishing Indo-Swiss Training Centre. While Indo-Swiss Training Centre has already started functioning from October 1963, other activities of the CSIO are being organized at present

Functions of CSIO

Broadly speaking, the organization has been set up for looking after all aspects of instruments industry from planning stage to distribution Activities of the organization can be summarized as follows:

(i) Survey and assessment of the present and future needs of various types of instruments, preparation of a phased programme of development of the industry, formulation and coordination of policies and procedures, distribution of instruments and regulation of imports, etc.

(ii) Preparation of technical and manufacturing know-how and testing techniques and production of prototypes.

(iii) Cooperation with Indian Standards Institution for the establishment of

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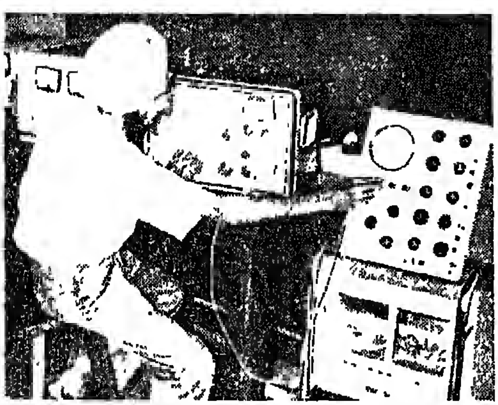
national standards for instruments and their implementation in cooperation with agencies like quality marking centres of state governments.

(iv) Organization of advanced training of technicians and specialized personnel required by the industry.

(v) Publication of appropriate bulletins, periodicals, etc

The service and maintenance units will be established by the Organization

Busy hands in Electronics Laboratory



at suitable centres throughout the country for repair of scientific instruments. The organization also participates in the development schemes of selected firms and encourages research efforts in the field of instrumentation by providing grants-in-aid to deserving parties

Location

Central Scientific Instruments Organisation is at present located on the ground floor of 30 Bay Building, Sector 17, Chandigarh and has ample accommodation for its present activities. The Indo-Swiss Training Centre is situated in Sector 30 where 120 acres of land have been acquired and the construction of the technological block will begin shortly.

Indo-Swiss Training Centre

A centre for training fine mechanics for instruments industry has been set up in Chandigarh as a branch of CSIO in collaboration with Swiss Foundation and has already started functioning with effect from October, 1963 The course for training is of three years' duration. Provision has been made to train 36 trainees every year to begin with.

The centre comprises of a large workshop measuring 3143 sq metres and an auxiliary building covering 1137 sq. metres with hostels for trainees, training school with class-rooms, drafting rooms, staff rooms etc.

CSIO Laboratories and Central Office

The laboratories, workshops and the central office of the organization are still in the process of development and are being set up with the assistance from the UN Special Fund. A good deal of the laboratory and workshop equipment for the organization is being

procured from abroad with the UN as well as our own resources. Equipment from indigenous sources is also being procured wherever possible. Appropriate staff for the organization is being recruited and will be trained locally with the help of UN experts. Besides this, there are a number of UN fellowships for the members of the staff. The following groups and sections of the organization have started functioning. Each group is assisted by one or more experts:

(1) The Optics Group is responsible for design, development, inspection and other activities related to optical instruments and industry.

(2) The Electricals and Electronics Group is responsible for similar problems related to electrical and electronic instruments and industry.

(3) The Central Workshop of the organization is being set up. This workshop will cater for the requirements of CSIO as a whole.

(4) The Metallurgy Section is being organized in Sector 30, Chandigarh in the premises of Indo-Swiss Training Centre.

(5) The Glass Technology Section is being set up for the fabrication of precise glass components (other than optical) for instruments.

Other groups/sections of CSIO will be set up in due course, when necessary facilities are made available.

The main emphasis of the CSIO is on the training of workers from industry in the know-how of instrumentation. The CSIO is co-operating with ISI in drafting and implementing Indian Standards for scientific instruments The organization will undertake design and development work as well as applied research as soon as necessary facilities are available.

For repair and maintenance of instruments, the CSIO plans to set up Service and Maintenance Centres at various places throughout the country. Two such centres, one in Delhi and the other in Madras, have already started functioning.

The CSIO encourages industry for developing new instruments by giving general guidance and also financial assistance to the extent of 50 per cent of the expenses to selected firms for establishing development centres. Three such centres, two in Ambala and one at Lucknow, have so far been approved.

The CSIO has given grant-in-aid to a research worker in connection with his research and development scheme connected with instrumentation.

Classroom experiments

An Improvised Wind Tunnel

R. Sudheer

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A FAIRLY simple wind tunnel can be made to study about lift and drag on an airplane wing (airfoil). Although the wind tunnel described below does not give accurate results, it does give a clear indication of the properties of an airfoil.

When I was building a glider, I became interested in the nature of lift. After building it, I wanted to learn how lift and drag change with angle of attack (the angle between the airfoil and the flow of air) velocity, different shapes, and flaps My science teacher, had a book which contained suggestions for building a simple wind tunnel to study these things. (Joseph, A. *et al*)

The items required to make the complete wind tunnel were: (i) a table fan, (ii) an airflow straightener; (iii) a platform balance; (iv) lift device; (v) drag indicator, (vi) airfoil (See figure on next page for details and arrangements.) I used very simple materials for these devices.

The Straightener

This makes the circular air stream from the fan straight The frame was from the plywood boards of a tea box, and the baffles insides were made with cardboard

The Balance

An old condemned platform balance was obtained from the school's laboratory. This was repaired and refinished. The original pans were removed and replaced by the stand for the lift device.

The Lift Device

Bernoulli's principle states that in a narrow place the velocity of a fluid stream increases while pressure decreases. The shape of the upper surface of the wing is similar to a narrow place, and so the pressure decreases on the top. The difference of pressure between the top and the bottom causes an upward force called lift. This upward force can be measured by placing the airfoil on a thin rod attached to a stand sitting on the balance (The airfoil is attached to the rod by a small bolt and the angle of attack can be changed by turning the wing about this point.) The weight necessary to balance the upward force will have magnitude equal to that of the lift.

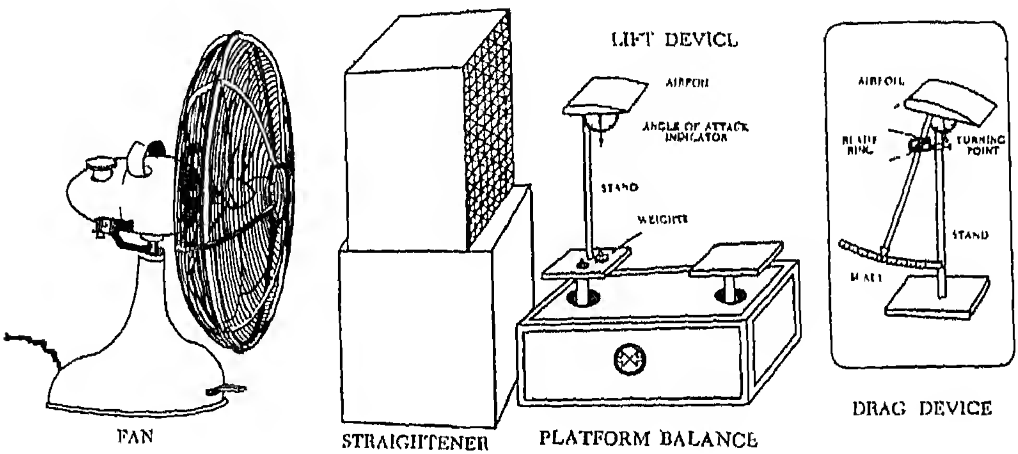
The Drag Indicator

Drag is the horizontal force opposite to the motion of the airfoil. A movement can be produced

by it if the wing is made to turn about a point under it. (The airfoil is attached to another thin rod through which a razor blade has been put. The blade rests on a notched metal ring fixed to a stand, and this arrangement makes the turning point.) The arc cut by the air foil will be proportional to the drag force producing it, and can be recorded on a scale below the end of the rod. The scale was calibrated in still air by noting the deflection caused by known weights.

unsteady in the centre, even with the straightener. This caused the drag indicator to oscillate unevenly, introducing error in reading the scale. For measurement of lift also, this unsteadiness caused the balance to oscillate. This, together with the balance's lack of sensitivity, allowed readings only to the nearest half a gram. Air speed was not uniform due to the difference in the current at various times.

In spite of these difficulties, I got



The Airfoil

The airfoil was made by cutting a balsa wood frame in the desired shape. The frame was covered with tissue paper and dipped to make it tight, strong and smooth.

In this wind tunnel lift and drag were measured separately for simplicity, but the two devices can be combined to measure lift and drag at the same time.

The following factors limited the accuracy of the results. Flow is a little

some interesting results. I measured lift and drag with different angles of attack and with different air speeds. I attached a flap to the trailing edge of the wing to find the effect of it upon lift and drag. (A flap is an extension to the wing which makes the shape of the wing change and causes a bigger pressure difference between the top and bottom surfaces.) I drew a graph to show lift and drag versus angle of attack, with and without flaps (see figure above).

In order to show the different

pressures on the surfaces of an aiifoil at diffeient distances from the front (lead-ıng) edge, I put some glass tubes in the wing and connected them to monometers wıth rubber tubes. However, I did not get good results because the aiı flow was too slow to show much change ın the monometer tubes. If a fastei air stream is provided, this appaıatus can nicely show the different pressures on the wıng—the principle by whıch lift ıs produced.

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Direct Reading Balance

P.S.V. Rao

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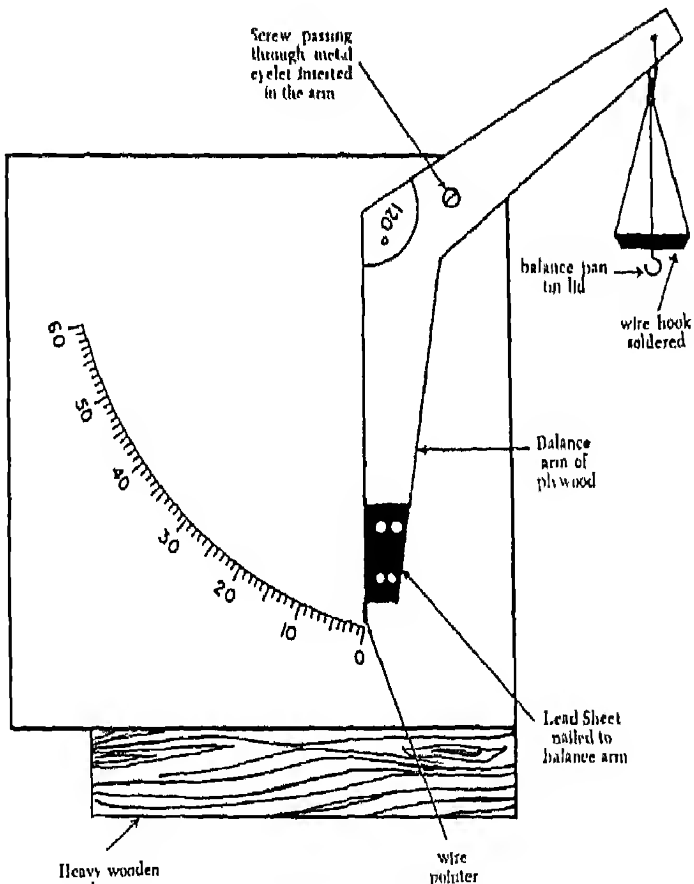
I am indebted to the 'Australian Science Teacher' for details of the balance. I have found it very useful to present the Principle of Archimedes to a large class It gives weighings up to 60 gram readıng to the nearest half a gram.

The scale is obtained by adding masses from 1 to 6 gms to the balance pan.

Additional equipment necessary to teach the Principle of Archimedes.

(a) Three solıds of the same volume but dıffering in mass.

Three Achromycin bottles (20 ml each) containing a different quantity of dry sand, cotton thread with a knot at one end is passed through the plastic lid and a loop is tied at the other end for weighing.



Direct Reading Balance

(b) Three solids of the same mass but differing in volume.

Three bottles made to weigh 50 g. wt. with dry sand (or lead shots).

The above figure shows the balance in action.

Science abroad

System of Teacher Training in the USSR

I. D. Zverev

UNESCO Expert (USSR) New Delhi

NATIONAL education plays an important role in the development of any country The USSR has made great achievements in this respect. Illiteracy in the Soviet Union was wiped out long ago. The following table testifies to the rapid development of education in the USSR.

Years	Number of pupils	Number of schools
1814-15	9,660,000	124,000
1940-41	35,550,000	215,000
1964-65	50,000,000	250,000

Such a rapid growth in the number of schools and in the number of pupils required a great number of teachers. This problem has also been solved successfully. At present there are 2,350,000 teachers working in the Soviet schools.

The problem of training qualified teachers is implemented chiefly by pedagogical institutes and universities. Teachers for the elementary schools are trained at pedagogical schools. Recently special departments have been opened in a number of pedagogical institutes at which teachers for the elementary schools get higher education. Teachers of science as well as those of humanities are trained at these institutes.

Now I would like to draw attention to the content and forms of training science teachers.

Profiles of Science Teacher Training

In view of the significant role that science is playing in the life of society, the training of teachers in physics, chemistry, biology and mathematics acquires special importance.

At present the training of science teachers is implemented according to the profiles shown below:

1. Mathematics, mathematics and technical drawing, mathematics and computing.
2. Physics, physics and electrical engineering, physics and astronomy.
3. Chemistry.

4. Biology and chemistry, biology and geography.

Teachers for the secondary schools are trained in one subject (mathematics, physics or chemistry), and for the middle schools in two related subjects.

Besides the branches of the department, there now exist branches for training teachers of physics, mathematics, chemistry, biology and geography in one of the foreign languages.

Curricula of the Science Departments

The curricula of science departments (mathematics, physics, chemistry and biology) are so worked out that the students after graduating get a sufficienty high scientific and pedagogical training. All the subjects of the curricula of the branches of physics, mathematics, biology and chemistry fall into three categories:

(a) Science subjects (65% of the study time)
(b) Social subjects (10% of the study time)
(c) Pedagogical subjects (17% of the study time)
(d) Foreign language and physical culture (8% of the study time).

As an example we may mention that the following branches of chemistry are studied in the department of chemistry: general and inorganic chemistry; organic chemistry with elements of biochemistry; analytical, physical and colloidal chemistry. In the department of biology, botany (anatomy and morphology, ecology, physiology of plants), zoology (invertebrates and vertebrates), anatomy of human body, physiology of animals and man, cytology and genetics, histology and embryology, and Darwinism are studied. Among social subjects we find political economy, philosophy, fundamentals of scientific communism, etc.

Pedagogical sciences include pedagogy, history of pedagogy, psychology, school hygiene, methods of teaching biology (or physics, or chemistry or mathematics). Reading of these subjects constitutes a very important part of pedagogical training of future teachers. These subjects develop students' ability to pedagogically contemplate and choose correct solutions of pedagogical problems; and they equip them with the necessary theoretical knowledge and practical skills to work with children.

Forms of Student Studies at the Pedagogical Institutes

The curricula envisage different forms of studies; many among them are lectures, laboratory work, seminars, practice at school, etc. On the whole the ratio of lectures to laboratory work, seminars and practice is 3:5. This ratio may vary depending on the profile and content of the subject. Besides, students who do their course and diploma work in this way carry out scientific research in a specific field. Students attend practical work in special subjects, and also work at optional subjects.

The work at course and diploma themes, practical work or optional subjects promote the students' skills of conducting scientific research in the

field of science as well as in the field of pedagogy. All the necessary laboratory equipment, materials, working place in labortories, possibility of participating in field expeditions, etc., are at the disposal of the students.

Some complex themes combining scientific and pedagogical research work are of high standard, *e g.*, listing of the mosses of a certain region and their study at school; the study of nature in the school neighbourhood and its study by the pupils in summer; construction of a working model of sulphuric acid plant and its use in a lesson; pupils' extra-curricular modelling in physics, etc.

The course work successfully completed by the second and the third year students may develop into diploma work which in the senior course may substitute one or two state examinations. The course or diploma work of the students is read at a meeting of the science clubs which exist at all the pedagogical institutes Besides this, inter-institute conferences of students' science clubs are held and sets of students' scientific research articles are issued.

Students' work at diploma themes and participation in students' science clubs are voluntary, but are greatly encouraged (official recognition on the success of students completion of scientific themes is by the award of free trips, etc). Students' participation in the work of students' science clubs facilitates the task of selecting gifted and talented students for scientific and research work thus systematically preparing scientific research cadres in science and pedagogy.

The pedagogical and school practice are of great importance. The main task of pedagogical practice is to teach students to employ their knowledge of pedagogy, psychology, methods and special subjects at school. During their practice students should learn how to conduct independent teaching and educational work at school and lead pupils. Well organized school practice facilitates inculcating in students love for the pedagogical profession and interest for scientific research in the field of pedagogy.

Students have their first 4-8 week summer pedagogical practice as pioneer leaders in pioneer camps. Students of the departments of biology and chemistry, geography and biology conduct pupils' summer work on school experimental plots. The second and the third pedagogical practices are conducted at school. At the departments with a four-year term of studies, the second practice is organized in the third course for 5-8 weeks and the third practice in the fourth course for 18 weeks. At the departments with a five-year term of studies, the second and the third practices are organized in the fourth and the fifth courses.

The content of all the types of practice is determined by the curriculum approved by the Ministry of Education.

Parallel with students' pedagogical practice, training in physics, mathematics and chemistry, they also carry out practical training at plants and factories; students in biology and

geography have their field training at biological stations. The terms for students' practical and field training are fixedin the different departments, e.g., for the students of the five-years term, departments of biology and chemistry envisage 21-weeks field training in agriculture and methods of teaching Biology and chemical technology are envisaged in the fourth course.

Evening and Correspondence Departments

Besides the training of teachers at regular full-time departments of pedagogical institutes, in-service teachers' training is implemented at evening and correspondence departments. The necessity of these forms of study is conditioned by a continuous increase in the number of students and in connection with it the evergrowing want of teachers with higher education. At present among teachers working at schools there are some who have not had any special education or those who have left the institute before graduating. They are given an opportunity to work and study at the same time.

As a rule every pedagogical institute has evening and correspondence departments. There is also one special Moscow Correspondence Pedagogical Institute. The curricula of five-year evening and correspondence departments are aimed at training teachers in one speciality (physics, mathematics, biology or chemistry).

The curricula of evening and correspondence departments are practically worked out in the same way as those of the corresponding regular full-time departments; only the number of hours is to a certain extent decreased. But it is worth noting that the syllabi of evening and correspondence departments do not differ from those of the corresponding regular full-time departments. This is affected by transferring certain themes of the syllabi from lectures and practical lessons to students' independent work of text materials. Hence, the control over independent students' work is significant at evening and correspondence departments. They have at their disposal special guide materials with instructions for independent work. Text materials, books on problems and practical work, guide materials for laboratory work in most important parts of mathematics, biology, physics and chemistry are being systematically issued. The Soviet Government are giving certain privileges to the students of the evening and correspondence departments. During the examinations students are paid their salary and they get free travel facilities.

Perfecting Teachers' Qualifications

In the Soviet Union, parallel with training new teachers, a great amount of work is carried out in perfecting theoretical, polytechnical and methods knowledge and skills of the teachers. Reorientation and refresher courses are conducted by District Teachers' Refresher Institute, local associations of education, school subject sections as well as by pedagogical institutes and partly by universities.

The reorientation of teachers is aimed at helping teachers and school officials to perfect pedagogical process and

conduct teaching on a level with modern achievements of science.

The following parts are envisaged in the syllabi of the courses:

1. Perfecting of teachers' scientific knowledge in the field of their subject. Acquainting them with the main achievements in science and technology.
2. Studying of the scientific bases of production.
3. Perfecting of the methods of teaching and educating pupils.
4. Perfecting of school leadership, control and instruction.
5. Exchange of experience.

The following methods are employed in improving teachers' qualifications

1. One-year course at the Teachers' Refresher Institutes.
2. One-month course for teachers and officials of school and local associations of education.
3. Regional Methods Sections at local associations of education.
4. Teachers' Methods Sections at schools.
5 Lectures, seminars, consultations at Teachers' Refresher Institutes and other scientific societies. The content of different forms of teachers' refreshing and reorientation varies and is determined by the level of teachers' knowledge, interest, time available, etc But the syllabus is discussed beforehand, worked out and effected by qualified lecturers and well-equipped laboratories.

An example of content of some key problems in the syllabus of teachers' refresher course may be as follows:

1. Review of the modern problems of science and technology.
2 System of education in the process of teaching science.
3. Development of the main concepts and skills.
4. Problem of the selection of methods and their correlation.
5. System of extra-syllabus of pupils' activities
6. New technical equipment in science education.
7. Methods of conducting excursions.
8. Preparation of teaching aids at the school workshop, etc.

The content of teachers' refresher course is closely inter-woven with the development of science, pedagogy and the whole system of education.

Science in the development of economy is putting forward before educationists new tasks All the time new problems appear aimed at perfecting and keeping abreast with the general progress of the society.

The Teaching of Science and Mathematics in the USSR

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GENERAL education in the Soviet system starts at the age of 7 years and is compulsory for eight years. The schools are usually of two broad types—one eight-year incomplete secondary school from classes I to VIII and the other from classes I to XI. The three classes IX-XI constitute the higher forms of secondary school. In many sparsely located areas there are primary schools of classes I-IV.

Of late there is a move to convert the 11 years of schooling to a period of ten years of schooling with the same amount of curricular offering and it is expected that in a couple of years from now all the schools will be converted to 10-year schools.

There are special secondary schools for 3 or even 4 years duration for those who want to go in for special vocational and pre-vocational courses after the compulsory eight-year schooling in the incomplete secondary schools. Those who want to go for general education or higher academic and professional courses pursue their studies in the general secondary schools to complete their matriculation which is the entrance requirement for all courses in the institutes of various kinds, as these higher educational institutions are termed.

The school year throughout the country starts on September 1. The school year in classes I-VIII is divided into four terms and for classes IX-XI into two semesters. The time for schooling is six working days a week and 34 working weeks a year for classes I to III and 35 for other classes. The school year closes on May 31 for classes I to IV and June 19 for V-VII and June 25 for class VIII. There are 25 days as holidays.

The school period is of 45 minutes followed by a break of about 10 minutes. There is a 30 minute recess for lunch. The schools start at 8.30 A.M. or 9 A.M.

Classes I and II have 24 school periods per week; class III 26 school periods per week, class IV 29 school periods per week; class V 33 school periods per week, classes VI-VIII 34 school periods per week; and classes IX-XI 38 school periods per week.

Curriculum in the Schools

The most significant feature of the Soviet system is that it has more or less a uniform academic programme for all its children, whether boys or girls, rural or urban. There are no optional or elective subjects. All the pupils receive

the same academic training in the school, there being no streaming at the school stage. Specialization is done after the school stage. No doubt there are some schools with special bias in certain subjects, like, say, physics bias, chemistry bias, mathematics bias, etc But the core of the programme is essentially similar. This unified curriculum not only offers the same body of knowledge and skills but also ensures a proper gradation vertically. It has been a powerful means for stabilizing standards, helping population mobility and for removing disparities in the levels of development in different parts of the country It should be, however, borne in mind that certain marginal changes are made to suit the special local requirements.

Primary Grades (Classes I–IV)

The aim of education here is to equip the child with 3 R's, to read well, to write correctly and to solve simple practical problems and finally to prepare for later mastery of fundamentals of science, and orient them for love of labour. The basic subjects studied are—Russian language (the local language), arithmetic, history, nature study, drawing, music, physical culture, craft work and socially useful work.

Science is taught as nature study only in Class IV for 3 periods a week out of 29.

Elementary Grades (Classes V–VIII)

The aim of education at this stage is to produce pupils who are fully literate in the broadest sense. There is greater emphasis on precision in contents and methods of teaching This stage has no responsibility of training pupils to any particular task or vocation but to acquaint them with various kinds of work, display their abilities with a view to complete the secondary education and choose a career

The basic subjects taught are Russian language, (in addition to national language of the Republic), Russian literature (national literature), mathematics, history, geography, biology, physics, chemistry, technical drawing, one foreign language, drawing, music, physical culture, craft, machine work and socially useful labour.

Total amount of time devoted to science and mathematics at this stage is 43 out of 135 periods per week in all four classes.

The total time allotted for instruction in science and mathematics out of general school subjects (excluding physical culture, labour training and socially useful work) in classes I to VIII amounts to about 40 per cent of the time.

Secondary Stage (Classes IX–XI)

The aim of education at this level is to educate comprehensively in the fundamentals of sciences and give them a firm grounding for the later task of research and specialization in the institutions of higher learning. It also trains a worker to master the habits and methods of work under conditions of mechanisation and automation. A substantial amount of time is devoted to practical productive work. This work is differentiated in urban and rural

schools in conformity with local conditions.

The subjects taught are: literature, mathematics, history, constitution of the USSR, economics geography, physics, chemistry, biology, technical drawing, foreign language and physical culture. The polytechnical training or agriculture (in rural schools) and socially useful work takes 33 school hours per week in the three classes. There is provision of 2 periods per week (or 6 in all the three classes) for optional work, for making a deeper study of any subject of choice from the curriculum.

Of the total time devoted to academic subjects, the time alloted to mathematics and science at the secondary stage amounts to about 49 per cent.

As it has been pointed out at the very beginning, the most significant feature of the Soviet school system is the polytechnical approach whereby the pupil makes socially useful and productive work and not only develops skills but learns the dignity of labour which becomes ingrained in his life. Every child undergoes labour training and works with his own hands in useful and constructive activities.

Salient Points in Science Teaching

It has already been indicated that science and mathematics occupy a very prominent place in the curriculum of the schools. Now the special features that characterize science teaching in the country may be considered.

(i) From the post-primary stage sciences are taught not as general science but as independent disciplines or subjects.

(ii) The syllabi of the sciences are modern and up to date. Supporting the syllabi are good and modern textbooks which are amazingly cheap, compared with our standards. There is a large volume of supporting literature for the use of the teacher to supplement the information and for guidance in teaching.

(iii) The approach of the syllabi is experimental in nature so that the concepts and ideas in sciences are built as a result of concrete experiences obtained by the pupils This approach essentially needs a supply of adequate equipment, physical facilities, and trained teachers. The country has ample supplies of all these essential components. The Soviet schools have developed the idea of work rooms or classrooms-cum-laboratories for the elementary classes, which is economic and functional. The pupils do not have to go to a sophisticated laboratory for doing experiments except in the higher classes.

(iv) The demonstration equipment for teaching various sciences is particularly impressive. They are large enough to be seen by a whole class, well built and sturdy and in most cases so constructed that essential parts can be seen and examined easily. These are standardized and manufactured on a large scale in state factories so that they are cheap.

The availability of such equipment is

a great boon for the teacher. It makes his task of teaching much easier.

(v) The teaching is inter-woven with everyday life and industry. To the child science becomes meaningful when he sees that it is not an abstraction but concrete and has use in all walks of life. Though sciences are taught as separate disciplines, the teaching correlates all sciences effectively and through work and applications, its impact on life is brought home. The labour training gives an idea of the use of science in industries and in other walks of life.

(vi) The method of teaching lays great emphasis on checking pupil knowledge constantly. From the earliest times, numerical concepts and problems are given so as to give a thorough grasp of the principles. There is an elaborate system of evaluating pupil knowledge by oral questions, written work, home assignments and control work. This aspect will be discussed in detail in another paper.

(vii) Great importance is attached to out-of-class activities in the form of excursions, visits to plants and explorations, in the teaching of sciences The importance of these is well known to all academically, but the point to note is that these are organized regularly so that they form an integral part of the teaching learning situation.

(viii) The examination system does not depend on one final evaluation at the end of the year as we have in most of our school systems There is a constant evaluation throughout the year and the progress of a child is determined by his performance in the whole session Secondly, there is a great emphasis on oral examination throughout the educational system

Co-curricular Activities

There are three main agencies that provide the school children to get rich and varied science experiences which go a long way to strengthen the science teaching. Through these the child is able to develop his creative ability, pursue independent investigations and do a variety of constructive work which satisfies his inner urges These are (i) Circle organization in schools, (ii) the pioneer organization and (iii) young technician stations

Evey educational institution has a number of circles under the supervision of specialists. They attend one or two circles twice a week for 2 hours each outside school There are a variety of circles (may be 20 in a school) some of which are related to sciences and workshops. Pupils are encouraged to develop individual projects. The young technician stations supplement the work of the circles especially in the fields of science and technology. These are located all over the country providing suitable tools and technical supervision and other facilities for circle work at an advanced level. In big cities there are central stations staffed by well-qualified and trained persons on a whole-time basis. They also prepare special literature and organize contests. The stations are not merely hobby clubs but centres of research and experiments conducted by pupils.

The pioneer organization is meant for the age-group 10-15. Every school has a pioneer organization with a whole-time person to organize and guide the activities. Practically all pupils are members Though in main the pioneer organization aims to develop studiousness, courtesy, discipline, love of labour, citizenship, cooperation and loyalty to the team and country, it plays a considerable part in training pupils in sciences through the network of pioneer houses and palaces throughout the country. The bigger ones in big cities called pioneer palaces are really bee-hives of activity, sometimes with hundreds of rooms with a similar number of circles where pupils are engaged in various activities A member attends the palace or house twice a week for about two hours. Many of the activities relate to science, like photography, electronics, radio making, television, chemistry, naturalist clubs, film making, gliding, aeronautics, astronomy, pet rearing. There are workshops of all kinds. There is always a good library of books, toys and indoor games. The activities of pioneer organizations are vast and their description is beyond the scope of this paper. The only point worth mentioning is that they make significant contribution in strengthening science teaching

The Teacher Training Programme

The teacher training programme of the USSR is radically different from our training programmes. In our country we expect the teacher to be adequately provided with content knowledge in the colleges and universities in various subjects This is followed by a one-year professional training course in a training college of some kind where emphasis is on educational psychology, history of education, principles of education, school health and administration and methods of teaching various subjects. This period of training is usually divorced from teaching content of any kind. In the USSR the teacher training programme is essentially a professional course lasting four to five years after the secondary school in a pedagogical institute. During this period the future teacher learns all the subject-matter at the degree level and the methods of teaching the subjects. There is a very functional integration of subject-matter and its methodology. All the skills that a teacher would need in his performance in the classrooms are developed in the course of the long period of training. This is like any other professional college that we have in our country in the fields of engineering, medicine or technology. The teacher gets a professional outlook from the very start and does not have to develop the same through the mill of actual service in the schools, as we have in this country. The four Regional Collges of Education that have been started in our country recently by the NCERT are somewhat on the same pattern, but the fact remains that they would supply only an insignificant part of our total teacher requirements.

The second feature of teacher training programme is the wide prevalence of evening and correspondence courses available all over the country for those who want to become teachers or improve their qualifications. Originally this was introduced as a measure of

removing the back log of untrained or unqualified teachers. But with experience the system has more or less come to stay as a permanent feature. For, in the field of education there are many people other than teachers who would love to become teachers or there are many teachers who by taking superior training can advance their positions. This provides a very suitable opportunity for such people to qualify for such a career, even when they are engaged in some other whole-time work during the day. Without going into the details of the organization and programmes I must limit myself to the observation that the standards achieved by these courses are very well comparable with the day courses and secondly a vast number of teachers are getting trained in this fashion.

The third feature of teacher training programme is the in-service education of the teachers. Every teacher in the USSR is obliged to undergo a refresher course in his subject once in every five years. This includes updating of content knowledge and acquaintance with modern techniques of teaching and teaching aids. The period of training may vary from one to three months according to plan Most of these refresher courses are organized by institutes of refresher courses which are permanent institutes with a large and adequately trained staff. Besides these regular courses, there are other in-service programmes of shorter duration from one day to a week according to subject needs and class levels on a city or zonal basis. These may be organized by institutes of refresher courses, pedagogical institutes or local pedagogical committees or administrative agencies. Many of these programmes are quite regularly held throughout the year and concentrate on methods of teaching and on problems of teachers of particular class or subject.

The fourth feature of teacher training programme that attracts attention is the availability of a large number of journals on specific subjects and also on general pedagogical problems. These journals keep the teacher abreast of the times, make him aware of the pedagogical advances in his subject, offer solutions of day-to-day problems in teaching, familiarize the teacher with the latest teaching aids and equipment and in a way continuously educate the teacher.

The greatest strength of a school system is the quality of the teacher in the system. With the best of curricula, text materials, teaching aids and laboratory equipment, it is still the teacher who has to translate and implement the objectives of education. The need is therefore to equip the teacher with the knowledge that he has to impart and the skill with which to impart the same.

Young folks corner

Test Your Knowledge

WHAT ARE 'QUASI STARS'?

FOR the past twelve months, astronomers have been talking of little else apart from 'quasi-stars'—faint pinpoints of light which have been photographed by the giant telecopes—which seem to represent some entirely new and unsuspected type of object in the universe.

From these 'quasi-stars' huge streams of enormously powerful radio waves are flowing. Furthermore, various measurements suggest that if you could get near them they would be found to be 100,000,000 times brighter and heavier than our sun.

None of the processes which are thought to go on inside, ordinary stars could possibly account for such luminosity, and such powerful radio emissions.

But strangely enough, before any 'quasi-stars' had been discovered, Professor Hoyle, together with an American scientist William Fowler, had suggested that, in theory, huge gas clouds in the universe might occasionally start to 'implode'—explode inwards—driven by the force of gravity. This, it turns out, would produce something remarkably like a 'quasi-star.'

Hoyle and Fowler were studying the process which normally leads to the formation of a galaxy of stars. A cloud of gas condenses and then breaks up into stars But occasionally, they decide, this break-up might fail to occur. The whole cloud would continue to contract, pulled by its own gravitational field, so that the whole mass would rush inwards with increasing speed and force.

Such an implosion would produce a most peculiar object, at the centre of which would be matter of inconceivable density. A fragment one-thousandth the size of a pinhead might weigh a million million tons.

Many physicists and theoreticians are now trying to work out in more detail what would happen inside such an imploding object. Hoyle and Narlikar think that matter might actually be squeezed out of existence, so to speak, and would vanish into what they call the Creation Field.

Distant Galaxies

It is out of this field, according to Professor Hoyle's celebrated theory of 'continuous creation', that matter continuously emerges to balance the

expansion of the universe which astronomers observe. It has long been realised that all the distant galaxies to be seen through large telescopes are receding from the earth, some with enormous speeds Without continuous creation, the universe would gradually get emptier. But according to Hoyle, the average density of matter in the universe is kept steady through 'continuous creation' of new matter.

Inside the 'quasi-stars' though, this process may be forced temporarily into reverse. Gravitational collapse may force some matter back into the creation field.

These are strange ideas but it is astonishing how they seem to fit the observations of 'quasi stars'. And they could help to account for the huge luminosity and the radio emissions of these objects.

Quasi-stars appear to be gravity powered—unlike ordinary stars which derive their energy from nuclear reactions. This makes new theories of gravity all the more significant.

Professor Hoyle believes that out of these new astronomical observations, combined with the new theories they are stimulating, profound implications for terrestrial physics may emerge. We are certainly living in revolutionary times, and our whole outlook on the universe may be very different in a few years hence, thanks to the activities of people like Hoyle and Narlikar.

Courtesy: Spectrum, September 1964.

WHAT IS CELLULAR RESPIRATION?

It is an energy-producing oxidative process by means of which carbohydrate fuel is ultimately converted into carbon dioxide, water, and chemical energy. Each step in the series of complicated and highly integrated reactions is under the control of a separate and specific enzyme.

Carbohydrates in the cytoplasm of living cells are broken down into simpler substances leading to the formation of pyruvic acid. This acid enters a mitochondrion which uses it as fuel for a series of cyclical chemical reactions collectively known as *Krebs* or *Citric acid cycle*. In this the pyruvic acid as well as amino and fatty acids (breakdown products of proteins and fats) are converted into simpler intermediate products of metabolism. These fuel fragments combine with molecular oxygen to form waste products, carbon dioxide and water. In this step hydrogen is removed from the fuel molecules. The chemical bonds of the fuel molecules are broken, releasing energy in the form of electrons. These join with ADP and phosphate to synthesize ATP molecules, the electrons becoming locked into the high-energy phosphate bonds of the latter. ATP is an energy-trapping device; it represents the end-stage in respiration. This mitochondrion is free to transport its concentrated packet of energy to portions of the cell where it is needed.

S DORAISWAMI

Science notes

THE LASER TO BURN A HOLE IN YOUR POCKET

Laser which has been produced by the Services Electronics Research Laboratory at Baldock, one of the naval research laboratories, can really burn things up at considerable distances 'It's the nearest thing I've ever seen to a death ray' were the words of a senior and sober industrial manager at Elliotts, who are developing this laser industrially.

This laser produces its beam of intense and very pure light from a mixture of two ordinary gases—nitrogen and carbon dioxide; gases which are in the air around us. Its great advance over previous lasers is that it can pour out very considerable quantity of electrical power and do it continuously. Other lasers—those using rods of bury or a special glass—have produced high power beams; but their beams last only for millionths of a second. If you attempt to prolong this minute time, ruby lasers stop working properly. Taken over a period the power is very small. Lasers made in the past using tubes of gas have produced only low power—but have done it continuously—and the same goes for the third type of laser that uses pinhead-sized pieces of transistor-like material.

The beam of light from this new gas laser is continuous invisible infra-red light and is very powerful indeed. By focussing it on a minute spot the laser can concentrate on to this spot energy equivalent to the entire output of a modern electric power station focussed on to a surface of one-tenth of a square metre. This means that the laser can burn. It can set fire to your cigarette or a piece of paper. But these things are just parlour tricks. Obviously, it could, if you were using it seriously, burn a nasty hole in an enemy, and it could do this at a range of several hundred yards, because it operates at a wavelength which travels well through the air. More usefully, it can cut plastics or wood with extreme precision, it can cut metal, or engrave glass; it can weld metal. One of its earliest practical applications that are foreseen for it, is sealing plastic bags—very humdrum, but it would be very efficient at this. In the more distant future it could be used instead of the surgeon's knife or scalpel for germ-free surgery.

ADVANCES IN TECHNIQUES OF SEISMIC SURVEY

Seismic surveys remain the most exact means for locating possible traps of oil in the rocks underground, but there are still areas incompletely explored because they produce seismic records that are unreliable on account of spurious signals corresponding to noise, multiple reflections or interference. A method of eliminating these unwanted signals

is the optical Laser Scan which is being used increasingly by Shell Companies. By means of this the spatially coherent light from a laser is passed through a 35 mm film transparency of the picture made by seismic echo of the earth sub-surface. The lines on the film behave as a diffraction grating. As a result, the laser light is modified, and the portion of modified light suspected of being caused by spurious data can be blocked out. Until the development of the laser, no source of light with sufficient intensity for this purpose was available.

THE ELECTRONIC BLACKBOARD

Sad news for the budding juvenile delinquent! The electronic age is catching up and tricks indulged in when teachers' back is turned won't be so popular in future. The teacher can now write an equation or draw an illustration on the blackboard that has gone electronic. One version of this new generation of blackboards was shown by EMI at a recent exhibition in London of closed circuit television equipment for teaching purposes. The teacher simply writes on a glass screen in front of him and the picture is shown simultaneously on the television screen watched by the class. The advantage of course is that more than one class can watch, possibly several classes in several schools. Illustrations can also be used. They are prepared beforehand on transparent material. It looks like a useful teaching aid in an age of too few teachers for too many pupils

HYPERSONIC FLIGHT

One of the problems facing designers of aircraft for speeds of Mach 4.5 and more is to provide for cooling of the aircraft's skin, engine walls and crew space. Aerodynamic heating may reach 1,400°C at Mach 6, for example, and 3,300°C at Mach 10.

Scientists and engineers at the Emeryville Research Centre, California are part of a team working under a contract from the United States Air Force to develop specifications for potential petroleum fuels that might be used at these high speeds, and at the same time act as heat sinks to cool the aircraft.

In a paper delivered recently to the American Chemical Society's Division of Petroleum Chemistry, the Emeryville team reported a method of using methylcyclohexane as a heat sink fuel. In the first instance, heat from the aircraft would be used to vaporise the fuel prior to passing it through a catalytic reactor. In this small reactor, further heat would be absorbed by an endothermic reaction that converts the methylcyclohexane into toluene and hydrogen, both good fuels for hypersonic (Mach 5 or above) aircraft. In this way, a sensible portion of the aerodynamic heat would be dissipated.

At Thornton Research Centre preliminary work is under way on another problem connected with high speed flight—the dissociation of the combustion products in a ram jet engine as a result of the high temperature produced, not only by combustion, but by the heat generated (1,000-2,000°C) in the compression of air entering the engine inlet. The heat energy tried up in these dissociated components represents a loss that

might otherwise be employed in developing thrust. It is true that some recombination takes place with the release of heat, but this does not normally reach maximum extent possible. Thornton is examining how the extent of this recombination can be affected by varying the composition of fuels or by the use of additives. In order to undertake these studies, the laboratory has designed and built the first pebble-bed regenerator to be successfully applied to combustion research in Europe. This bed is used to heat the air before it is mixed with the fuel in a combustion unit. The temperature patterns and reactions occurring in the combustion rig will be monitored by spectroscopic methods.

A NEW CONTAINER TO PRESERVE MILK QUALITY

A new type of milk container has been developed by the Koninklijke/Shell Plastics Laboratorium, Delft. Made from a polyethylene film which is produced by a special technique it is black on the inside and white on the outside. This film, only 0.09 mm thick, excludes light which is especially detrimental to the quality of milk.

Milk in ordinary bottles loses more than 80 per cent of its valuable Vitamin C when exposed to daylight for three hours. Light can also cause an undesirable 'light taste' due to a photochemical reaction in the riboflavin (Vitamin B_2) present in milk. In the polyethylene sachet on the other hand the Vitamin C content is reduced by only 5 per cent after 3 hours' exposure to daylight.

The sachet, which is now being introduced in the Netherlands, has many other advantages over conventional milk bottles; it is very light, disposable, easily stored and unbreakable.

Courtesy: Indian High Commission, London.

News and notes

SCIENCE AND MATHEMATICS TEACHINGS PROJECT UNDER THE UNESCO TECHNICAL ASSISTANCE PROGRAMME

THE four teams working in collaboration with the Unesco experts continue to prepare and try out the text materials in biology, chemistry, physics and mathematics. These materials have been printed in Hindi and distributed to the students and teachers. The illustrations for these text materials were selected and drawn in the department.

The teachers of the different disciplines under the experimental project are meeting once every week Here they are familiarized with the new teaching materials and the modern techniques of teaching the same. The participants are also asked to conduct experiments under the supervision of the team of experts. Notes of lessons and instructional materials are given to them at these meetings. The experts are also visiting the schools during their working hours.

On the basis of the teaching materials a half-yearly evaluation was conducted during December, 1965. Most of the participant teachers have reported successful evaluation. The results of their performance are now being analyzed with a view to further improve this syllabus and materials

GENERAL SCIENCE

A guide book for teachers of general science in classes I to V is being developed for the use of primary school teachers based on the draft syllabus of general science already published by the NCERT. This book will be a companion columе to *'General Science-Handbook of Activities–Classes VI to VIII* already published by the Council.

WORKSHOP OF SCIENCE CLUB SPONSORS

A workshop of Science Club Sponsors from the states of Mysore, Kerala and Madras was organized from 19 to 28 December 1965 at the Madras Christian College High School, Madras Twenty-one teachers participated in this workshop and they were initiated into skills in carpentry, sheet metal and electric winding. The sponsors were also trained in the techniques of organizing investigation types of projects at the school level Outlines of more than 100 such projects were developed by the participants and these will be tried out by them in the schools. The report of the workshop along with the projects was presented at the valedictory function which was addressed by Shri M. Bhaktavatsalam, Chief Minister of Madras on the last day. Shri V. T. Hitus, Director of Secondary Education inaugurated the workshop on the 19 December, 1965.

UNESCO TECHNICAL ASSISTANCE PROGRAMME

Dr. G. Maslova, one of the Unesco

experts, working with the Department from the beginning of the year' left for Moscow after completion of her term of assignment. Dr. S. V. Nazariev, Chancellor of the Ozehovo-Zuvsey Pedagogical Institute and Dr. V. J. Michine, Moscow State Pedagogical Institute joined the team of experts in the month of December, 1965. The former is the leader of this team.

In October, 1965, three members of the Department of Science Education, NCERT, namely, Shri G. Raju, Shri K. J. Khurana and Shri K. S. Bhandari left for a six months' training in the USSR under this scheme.

Books
For your science library

Senior Science for High School Students. Part I – Senior Science Textbook of Authors and Editors. *Physics Nuclear Research Foundation, University of Sydney, New South Wales,* 1966.

Recently attempts have been made in various countries to produce textbooks for physics, chemistry, biology and mathematics with the collaboration of university and college professors and school teachers. The first step in this direction was taken in the USA where the textbooks along with teacher's guides were prepared a few years back after actual trials of the preliminary editions in schools. A similar step has been undertaken by the Nuffield Foundation, but so far no books have been published by the second group.

Some years back, the Nuclear Research Foundation of the University of Sydney, New South Wales, produced a composite book entitled *Science for High School Students.* This book dealt with not only physics, chemistry and biology but also with astronomy and geology. The present book on physics is a continuation of the previous book and takes a four-year science course through to the end of the sixth year of secondary schooling. Whereas in the first book the idea was to present a connected account of all the branches of science bringing out their inter-connections, the present book is meant for teaching physics as a special subject. Of the five authors connected with the writing of the physics book, four are university teachers and one is a school teacher.

The book deals with some of the advanced topics which are ordinarily taught in our universities in the B.Sc. (Pass and Hons) classes. There are two chapters on the 'Theory of Relativity' and four chapters on what is generally called 'Modern Physics.' After mastering this book a student should be in a position to clearly understand any book on modern physics which does not involve difficult mathematics. Each chapter ends with suggestions for practical work and suggestions for further reading. One of the books suggested for further reading is Richtmyer, F. K. and Kennard, E.H. *Introduction to Modern Physics,* McGraw-Hill, 1947 which an ordinary student might find difficult

The book has been well illustrated especially with regard to diagrams explaining the fundamental concepts of physics.

Some of the ideas introduced are not generally found in a physics book. One example of this is the discussion of Olber's paradox which could not be explained by the ideas of the 19th century but has now been explained by the concept of the expanding universe.

Throughout the book the authors use the M.K.S.O. system. It is, therefore, unfortunate that no clear definitions of coulomb and ampere have been given in the book. It is stated on page 64 that the experimentally determined value of K, in the equation $F=\frac{1}{K}\frac{Q_1Q}{r}$, is $1.12\text{x}10^{10}$. But this pre-supposes the fixing of the value of the coulomb and this has not been done.

It is felt that the book will be found useful both to teachers and students and should find a place in a library.

R. N. RAI

Concept in Science, Vols. 1–6 : BRANDWEIN, P.E., COOPER, E.K., BLACKWOOD, P.E. and H*&5, E. B. *Harcount Brace & World, Inc. New York*, 1966.

Volume I :	
Volume II :	T. E. pp. 184
Volume III :	pp. 314+TE pp. 133
Volume IV :	pp. 314
Volume V :	pp. 376+T.E. pp. 198
Volume VI :	pp. 430+T.E. pp. 171

(T.E.=Teacher's Editions).

The vast disciplines of science are everyday gathering more and more bewildering data. Yet in this mass-accumulation of facts there are certain concepts of science that remain comparatively stable. These concepts offer a very good frame of foundations for building a science programme.

This series presents an elementary school science programme with a curriculum structure upon a framework of such concepts. From the previous child-centre approach there is now a shift to a process-centered approach, that is the content is being given more important role in the curriculum so that the interaction between the discipline and the pupil in the process of learning receives a major emphasis.

The present set has selected the following six major conceptual schemes :

1. Conservation of energy
2. Conservation of matter
3. Inter-dependence of living things with environment and other living things.
4. A living thing is the product of its heredity and environment
5. Living things are in constant change
6. The universe is in constant change.

Each conceptual theme is further developed in six concept levels with increasing complexity in an *ad hoc* order of precedence. The levels form rungs of a ladder so organized that the understanding of one precedes for the comprehension of the next. Each concept has a number of such concepts.

The treatment of the subject matter is activity-oriented so that the children participate in the activities and perceive

objectives, events and phenomena. The emphasis is on the scientific approach of investigation including observation, investigation, collection of relevant data, description of results, discussion of findings, confirmation of findings, reading the work of scientists, reporting of work and within limits experimentation

The textbooks are profusely illustrated with very graphic and realistic, coloured diagrams and actual situation photographs. The language of the books is well graded according to the class levels Each section ends with exercises on 'Testing Yourself', 'Further Readings' and suggested continuing activities. At the end of each volume is a detailed glossary of key-concept words so that accuracy in expression results.

Each textbook has got a companion teacher's guide which gives the teacher valuable background, information and suggestions for introducing the lesson, developing the concept and extending the concept through investigations, key-concept words, suitable readings and thorough development of mental models to clarify the concepts.

The get-up and printing of the books are excellent.

It is expected that the series will form a rich resource material of activities for the trainees of the Teacher Training Institutions for preparing general science teachers for the primary and middle grades.

N. K. SANYAL

Great Discoveries by Young Chemists. KENDALL, J. *Thomas Nelson and Sons, London,* 1953. pp. 230.

This volume is an interesting narrative of the development of chemistry in the last 200 years through the biographies of some eminent chemists. The author has given a course of lectures adapted to a 'Juvenile Auditory' delivered at the Royal Institution in 1938. The style of the lectures has been changed into a narrative form and is well suited for a juvenile reading group. The intimate biographical details of the most important chemists have been presented and a continuous historical development of the main currents of chemistry has been maintained. The emphasis has been given to the predominant part played by young chemists in the development of their science. Interesting and authentic biographical anecdotes make the narration very attractive. Among the chemists whose biographies are included are Davy, Faraday, Perkin, Hoffman, Couper, Louis Pasteur, Van' Hoff, Kekule, Ostwald, Mendeleef, Mosley, Madame Curie, Ramsay, Langmuir, Martin Hall, etc.

The author has tried to give an account of the actual experimental work and the process of investigation as a basis for the development of the subject.

The chapters on 'Chemistry of solutions' and 'Elements old and new' give a lucid account of how modern ideas were evolved through the pioneering efforts of some of the brilliant

chemists of the day. Towards the end the author has given how the first chemical society and first chemical journal were developed in England.

This book will be a valuable source of information and inspiration for the students of the higher secondary classes; for the teachers it will give authentic sources of the origin of many of the historical developments of chemistry and be of great help in preparing teaching materials.

The volume is recommended as a suitable reference book for all school libraries where science is taught.

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